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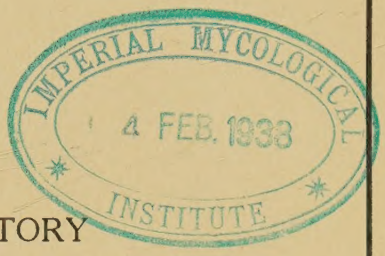

TANGANYIKA TERRITORY

DEPARTMENT OF AGRICULTURE

Third Annual Report of the Coffee Research and Experimental Station, Lyamungu, Moshi 1936

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SECTION I.—Administration.

Introduction.

Owing to the increased results available this, the third annual report of the Coffee Research and Experimental Station, is published separately as a bulletin. As the coffee harvest in the higher altitudes finishes in late January, the 31st March has been chosen as a more suitable date at which to report on the preceding year's work.

The lines of work now opened up fully occupy the resources of the present staff. No further developments can start without increase of personnel.

Table 1.

Leave Movements of Staff.—	Departed	Returned
The Chief Scientific Officer (S. M. Gilbert) ...	29-4-36 ...	5-11-36
Entomologist (F. B. Notley)	— ...	31-10-36
Chemist (H. B. Stent)	5-7-36 ...	—
Agricultural Officer (F. R. Sanders)	— ...	8-3-36

Staff Changes.—Owing to the sudden and lamented death of Mr A. H. Ritchie on the 20th February 1936, the appointment of an entomologist was vacant until the 31st October when Mr F. B. Notley, from the Kenya Department of Agriculture, was appointed to fill the vacancy. There is therefore no Entomologist's report for 1936.

Publications.—Monthly notes have been issued regularly to planters throughout the year.

Papers by the Chief Scientific Officer and Plant Pathologist have been published in the *East African Agricultural Journal.*

Visitors.—Dr M. Case, Biochemist to the Kenya Coffee Board and Mr F. J. Nutman, Plant Physiologist, Amani, were in residence as visiting workers for six months and five months respectively. Such visits are useful stimuli to the staff.

The following visited the station during the year:—

His Excellency the Governor, Lady MacMichael and party; the Treasurer; the Director of Agriculture; the Acting Director of Agriculture; Mr C. Gillman; Deputy Director of Agriculture, Uganda; Mr F. S. Joelson, Editor of *East Africa*; Acting Provincial Commissioner; Conservator of Forests; Acting Director of East African Agricultural Research Station; Deputy Director of Agriculture, Kenya, and many planters.

Buildings.—An insectory and fumigatorium have been constructed. Plans for the coffee factory have been finally approved but work has not yet commenced. When this is finished the authorized programme of construction will have been completed.

Finance.—A fourth annual grant amounting to £4,000 was received from the Colonial Development Fund. The analysis of expenditure is shown in Appendix I.

Board of Governors.—The second meeting of the Board of Governors was held at the station on the 18th May 1936, when routine matters were discussed. The members of the board remained the same as detailed in the first annual report.

Touring.—Periodical visits were made by members of the staff in connection with uniformity trials, current experiments and the preparation for additional experiments. A visit was paid to the Usambaras to investigate a new development in coffee disease referred to as "Collar Dry Rot" and at Engare Olmotonyi where a soil investigation was conducted by the chemist. In all some two hundred visits to estates were made by officers of the station.

SECTION II.—Review of the Year's Work.

Station Development.—The policy has been rather that of consolidation than of opening up fresh land. Efforts to get areas evened up for further experiments have been considerably handicapped and have proved very expensive because of the presence of dense patches of "singari" (*Digitaria abysinnica*). Fresh infections are brought in by the numerous water furrows, not under our control, which traverse the station.

Table 2.

Development	Acres
Forests (to be left untouched)	30
Planted with coppices, wind belts, etc.	20
In course of evening up for experiments	127
Nurseries	3
Coffee	32
Paddocks	9
Roads, buildings, gardens, etc.	25
Unopened up, other than forests	64
Total Area ...	310

Meteorology.—The long rains were even heavier than last year amounting to 58·5 inches by the end of May. The short rains only precipitated six inches. The total rainfall for the year was 89·31 inches. Outstanding features of the year were unseasonably heavy rain in February, the absence of the usual cloud "blanket" in the morning for the greater part of the period July to October, and the torrential long rains. As in 1935 the weather has been thoroughly unsuitable for establishing young coffee.

Interesting soil temperatures have been recorded as between mulched and unmulched (clean weeded) plots. The outstanding feature is the cooling and steadying effect that banana mulch has on the more shallow soil temperature in the hot season.

Table 3 summarizes the meteorological data for 1936.

TABLE 3.—*Meteorological Summary for the year ending the 31st December 1936.*

Month	Mean Maximum	Mean Minimum	Humidity		Sunshine	Rainfall
			9 a.m.	3 p.m.		
	—	—	%	%	Hours	Millimetres
January	26·1	15·1	81	71	177	83·3
February	26·1	15·4	79	68	130	135·1
March	26·1	15·2	81	65	177	57·9
April	23·4	16·1	94	78	71	752·5
May	21·6	15·3	94	78	42	675·4
June	20·1	14·3	90	73	52	222·0
July	19·7	13·3	89	65	62	106·7
August	20·9	12·4	87	59	108	60·1
September	22·6	13·0	86	63	152	19·8
October	26·2	12·5	76	47	253	5·5
November	27·9	14·0	74	53	204	10·3
December	27·6	14·5	77	59	220	140·0

Investigations.—In pursuance of the programme laid down in Bulletin 15 steady progress is to be recorded.

(a) IMPROVEMENT OF PLANT MATERIAL.

1. *Selections.*—Individual tree yields have been recorded for a further season completing three years for sixteen estates and two years for twenty estates covering some ten thousand trees.

Bean statistics have been worked out on 547 samples covering 129 trees. As a result of this work about a hundred provisional selections have been made, the criterion being at least fifteen hundredweights of clean coffee of good size annually for three years. These trees are undergoing further tests. In the meantime they are being propagated by seed, open and self fertilization, by rooted cuttings and by grafting on stocks, for study of their progeny in the field. Certain high yielders have also been cross fertilized.

Proof has been obtained over a three-year period, on several estates, that a large percentage of the trees are not profitable. Some evidence has also been collected to show that certain trees tend to remain relatively poor and that good trees seldom fall into the "poor" class. A separate article is being prepared on this matter. Selection work for the replacement of poor bearers in existing coffee therefore remains very important.

2. *Cross-breeding.*—Under this head may be reported that about eight acres of hybrids bred by the Geneticist, Amani, have been planted out.

3. *Introductions.*—The coffee variety garden now comprises fourteen species covering some forty varieties and types—see list in Appendix II.

(b) IMPROVEMENT OF GROWING CONDITIONS.

1. *Experiments on Estates.*—Work on uniformity trials has continued on the twenty estates as mentioned above. As a result of this work treatments may now be applied.

By the method of co-variance it is confidently expected that reasonable orders of increase due to treatments will be demonstrable.

2. *Station Work.*—The agricultural officer describes this work in Section Vc.

Miscellaneous.—Studies of shade trees and cover crops continue. Appendices III and IV give details of introductions.

(c) Vegetative Propagation.

Propagation by the rooting of cuttings is now a routine matter. Weather has been against growth and in consequence a second generation by rooting suckers from layered clones has yet to be established. Grafting in the field has made only fair progress and more investigation is necessary before success on a commercial scale can be claimed. With material now established on the station all work in this section will be facilitated and, it is expected, accelerated.

(d) Soil Investigations.

These are described under the following headings:—

1. The effect of cultural operations on soil moisture conditions and the liberation of soil nitrates at Lyamungu.
2. Survey of soil conditions in connection with uniformity trials.
3. Soil conditions affecting over-bearing and die-back in Arusha ash soils.
4. Soil conditions conducive to preponderance of vegetative growth over fruiting in Mufindi.

(e) Plant Pathology.

The Plant Pathologist has continued work on *Hemileia*. The necessity for Bordeaux spraying is confirmed. There appears to be no advantage in using spreaders, which agrees with Mayne's work in Mysore.

The help of all my colleagues is gratefully acknowledged as is also the useful co-operation of the district agricultural staff.

Lyamungu
31st March 1937

S. M. Gilbert
Chief Scientific Officer

SECTION III.—Improvement of Plant Material.

Selection.—During the course of the year a certain amount of criticism of the following nature has arisen among planters. What is the use of aiming at increased yields of *coffea arabica* and ignoring quality when the world supply is already too great? This is a misconception of the aim of the station. The aim, as stated in the 1935 report, is to increase the unit area "productiveness" of good quality coffee thereby reducing costs of production and enabling planters better to meet competition from anywhere. The programme of work is framed to that end.

Most estates have areas to a varying extent on which coffee should not be growing. It is sound economics to concentrate resources on good coffee growing under suitable conditions.

Selection work is unpopular with planters because of the number of years necessary to obtain results. It should be remembered in this connection that up to the present no special survey of existing coffee has been made in order to select "mother" trees. Such selections as have been made tentatively have arisen from the records for uniformity trials, and these records were essential to the experimentation on estates which *will* bring results of more immediate use to planters. It is seen then that no important resources have been specially diverted to selection work. Some hundred trees situated in all parts of Tanganyika Territory have been provisionally selected on their behaviour over three years. Observations on and collection of records from these trees continue. Table 4 gives the performance to date of such of them as have been accepted.

TABLE 4.—*Cherry yield in Ounces.*

Tree No.	Type	Spacing in feet	1934	1935	1936	Mean	Mean cwt. per acre	Altitude in feet	Soil	Age years	Shade
F 689	Kents	10	380	268	313	320	15·5	3,900	Red chocolate clay loam volcanic.	10	Yes
H 61	,,	,,	716	27	243	329	16·0	4,500	Chocolate red loam volcanic.	11	Few
102	Bourbon	8	600	37	274	304	19·0	,,	,,	,,	,,
133	,,	,,	733	48	208	330	20·6	,,	,,	,,	,,
I 56	,,	,,	700	2	392	365	27·7	,,	,,	12	Yes
128	,,	,,	449	31	385	288	21·9	,,	,,	,,	,,
235	,,	,,	617	65	191	291	22·1	,,	,,	,,	,,
428	,,	,,	563	133	247	314	23·8	,,	,,	,,	,,
J 49	,,	10	814	1	116	310	15·0	,,	Chocolate red sandy clay loam volcanic.	14	,,
L 1	,,	8′5″×6′5″	192	452	264	303	26·6	4,100	Dark chocolate brown clay loam moderately friable. Volcanic.	25	Yes
M 218	,,	9′ 9″	705	8	220	311	15·6	,,	Dark chocolate clay loam volcanic.	12	,,
381	,,	,,	787	42	191	340	17·1	,,	,,	,,	,,
N 5	,,	Varies	608	52	520	393	27·2	4,300	Light brown chocolate friable loam.	45	No
10	,,	,,	811	76	339	409	28·3	,,	,,	,,	,,
16	,,	,,	619	47	428	365	25·3	,,	,,	,,	,,
17	,,	,,	581	32	589	401	27·7	,,	,,	,,	,,
18	,,	,,	520	48	529	382	26·4	,,	,,	,,	,,
20	,,	,,	838	13	732	528	36·5	,,	,,	,,	,,
29	,,	,,	625	45	435	368	25·4	,,	,,	,,	,,
30	,,	,,	488	131	412	344	23·8	,,	,,	,,	,,
33	,,	,,	482	5	410	366	25·3	,,	,,	,,	,,
34	,,	,,	879	82	478	479	33·2	,,	,,	,,	,,
36	,,	,,	624	65	236	308	21·3	,,	,,	,,	,,
39	,,	,,	676	120	462	419	28·9	,,	,,	,,	,,

TABLE 4.—*Cherry yield in Ounces.*—contd.

Tree No.	Type	Spacing in feet	1934	1935	1936	Mean	Mean cwt. per acre	Altitude in feet	Soil	Age years	Shade
50	Bourbon	Varies	628	393	77	366	25·3	4,300	Light brown chocolate friable loam.	45	No
53	,,	,,	558	133	485	392	27·1	,,	,,	,,	,,
69	,,	,,	494	217	261	324	22·4	,,	,,	,,	,,
71	,,	,,	444	278	390	371	25·7	,,	,,	,,	,,
76	,,	,,	694	53	365	371	25·7	,,	,,	,,	,,
77	,,	,,	615	169	412	397	27·5	,,	,,	,,	,,
81	,,	,,	425	296	348	356	24·6	,,	,,	,,	,,
100	,,	,,	838	37	361	412	28·5	,,	,,	,,	,,
106	,,	,,	637	40	438	372	25·7	,,	,,	,,	,,
115	,,	,,	504	51	390	315	21·8	,,	,,	,,	,,
119	,,	,,	661	16	461	379	26·0	,,	,,	,,	,,
128	,,	,,	617	1	337	318	22·0	,,	,,	,,	,,
167	,,	,,	618	39	338	332	23·0	,,	,,	,,	,,
176	,,	,,	732	50	204	329	22·8	,,	,,	,,	,,
181	,,	,,	648	271	26	315	21·8	,,	,,	,,	,,
182	,,	,,	700	16	446	387	26·8	,,	,,	,,	,,
197	,,	,,	555	314	405	425	29·4	,,	,,	,,	,,
198	,,	,,	721	1	338	370	25·6	,,	,,	,,	,,
200	,,	,,	588	24	362	325	22·5	,,	,,	,,	,,
203	,,	,,	603	21	291	305	21·1	,,	,,	,,	,,
211	,,	,,	638	23	315	325	22·5	,,	,,	,,	,,
213	,,	,,	684	8	441	378	26·2	,,	,,	,,	,,
215	,,	,,	616	3	419	346	23·9	,,	,,	,,	,,
217	,,	,,	589	92	168	283	19·6	,,	,,	,,	,,
219	,,	,,	858	11	562	477	33·0	,,	,,	,,	,,
220	,,	,,	607	7	370	328	22·7	,,	,,	,,	,,
229	,,	,,	750	—	554	435	30·1	,,	,,	,,	,,
235	,,	,,	555	46	303	301	20·8	,,	,,	,,	,,
P 80	,,	10	395	360	401	385	18·7	4,600	Bright red clay loam.	10	Yes

TABLE 4.—*Cherry yield in Ounces.*—contd.

Tree No.	Type	Spacing in feet	1934	1935	1936	Mean	Mean cwt. per acre	Altitude in feet	Soil	Age years	Shade
147	Bourbon	10	488	470	75	344	16·7	4,600	Bright red clay loam.	10	Yes
190	,,	,,	320	329	354	334	16·1	,,	,,	,,	,,
280	,,	,,	384	376	317	359	17·4	,,	,,	,,	,,
287	,,	,,	328	312	287	309	15·0	,,	,,	,,	,,
313	,,	,,	384	466	216	355	17·2	,,	,,	,,	,,
348	,,	,,	388	450	161	333	16·2	,,	,,	,,	,,
351	,,	,,	397	401	176	325	15·8	,,	,,	,,	,,
R 1	,,	8	—	279	764	348	26·4	6,000	Red chocolate clay loam volcanic.	40	No
3	,,	,,	—	473	532	335	25·4	,,	,,	,,	,,
4	,,	,,	—	320	575	298	22·6	,,	,,	,,	,,
11	,,	,,	—	721	155	292	22·2	,,	,,	,,	,,
13	,,	,,	—	1,081	52	378	28·7	,,	,,	,,	,,
35	,,	,,	—	222	752	325	24·7	,,	,,	,,	,,

Material of all potential selections is being collected at the station to facilitate future work. It is being propagated by all known means. See below.

TREE NO.....

		Year	Cherry in oz.	Per cent clean to Cherry	Cwt. per Acre
Estate	.....	.....	.....	.....	.....
Type	.....	.....	.....	.....	.....
Soil Type	.....	.....	.....	.....	.....
Elevation	.....	.....	.....	.....	.....
Shade	.....	.....	.....	.....	.....
Irrigation	.....	.....	.....	.....	.....
Cultural	.....	.....	.....	.....	.....
Spacing	.....	.....	.....	.....	.....

PROGENY

Open Pollination (1)		Selfed (2)		Grafted or Budded (3)		Rooted Cuttings (4)		Clones of 4 (5)		♀ × ♂ N 31 (6)	
Year	Plot	Year	Plot	Year	Plot	Year	Plot	Year	Plot	Year	Plot
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Block		Block		Block		Block		Block		Block	

So far the discussion has centred on cherry yield. In 1935 examination of bean characters was initiated. This work has continued in 1936. Owing to biennial bearing seasonal comparisons have proved difficult. Trees that in 1935 gave ample material for several pickings this year gave only one or two. As "time of picking" affects bean characteristics considerably, very little could be done this year on seasonal effects.

Below is discussed the data accumulated on the samples of cherry brought in from the selected trees. The number of trees worked on is 129 and the number of pickings (samples) 547.

The characters recorded have been, as in 1935, weight of parchment to cherry, weight of clean coffee to parchment and to cherry, percentage peaberry and other grades, length, width, boldness, weight of bean and an estimate of volume with a view to working out density.

ANALYSIS OF DATA—BEAN STATISTICS.

(A) *Constants Calculated.*—It is obviously not possible to measure individually every bean for every picking on every tree which may be a potential selection. It was therefore necessary to find out what number of beans in a sample would be sufficient to characterize a tree. The number (N) had to be sufficiently large easily to make twice the standard error of the difference between means less than the specified difference decided on. Accordingly the crop of certain trees was studied in detail.

The following constants were calculated:—

(i) *Weight of Bean.*—In this case, owing to the labour involved, a sample of two hundred beans from each picking was assumed to characterize the crop of any one tree.

Below are the frequency tables for two trees. The range is enormous but the co-efficient of variability in no instance exceeds nineteen per cent. The sample is sufficiently accurate for the purpose in mind.

FREQUENCY TABLE 5A.—*Tree No. N30*

Weight of Bean (Grammes)

Mid value	Pickings 2	3	4	5
·075	—	—	—	—
·085	1	—	—	—
·095	—	—	1	1
·105	5	5	4	3
·115	5	13	5	8
·125	16	25	19	31
·135	26	14	12	31
·145	45	28	41	36
·155	29	34	28	34
·165	39	48	53	18
·175	11	16	15	18
·185	10	6	14	7
·195	3	4	3	2
·205	2	1	3	2
·215	1	2	—	3
·225	2	2	—	1
·235	1	1	—	—
·245	2	—	1	4
·255	1	—	—	1
·265	—	—	—	—
·275	—	—	—	—
·285	—	1	1	—
·295	—	—	—	—
·305	—	—	—	—
·315	—	—	—	—
·325	—	—	—	—
·335	—	—	—	—
·345	1	—	—	—
	200	200	200	200
Corrected estimate of mean	0·155	0·153	0·155	0·150
Standard deviation	0·0285	0·0252	0·0231	0·0280
Standard error	0·00201	0·00178	0·00164	0·00198
Co-efficient of variation	18·43	16·51	14·90	18·71

FREQUENCY TABLE 5B.—*Tree No. F502*

Mid value	Pickings 2	3	4	5
·075	—	—	—	1
·085	1	—	—	1
·095	7	1	1	3
·105	22	4	5	7
·115	22	17	7	15
·125	39	28	11	14
·135	32	23	24	14
·145	27	31	29	30
·155	21	35	42	29
·165	15	21	42	33
·175	5	16	29	12
·185	5	13	5	17
·195	2	2	4	7
·205	1	4	—	8
·215	—	1	—	4
·225	—	2	1	3
·235	—	—	—	—
·245	—	—	—	—
·255	—	—	—	1
·265	—	1	—	—
·275	—	1	—	—
·285	—	—	—	1
	200	200	200	200

Corrected estimate of mean	0·136	0·150	0·154	0·156
Standard deviation	0·0225	0·0270	0·0201	0·0294
Standard error	0·00159	0·00191	0·00142	0·00208
Co-efficient of variation	16·60	17·75	13·08	18·89

FREQUENCY TABLE 6A.—*Tree No. 30.*

Length of Bean.

Mid value mm.	Pickings 2	3	4	5	6
6·3	—	—	—	—	1
6·5	—	—	—	—	—
6·7	—	—	—	—	—
6·9	5	—	—	2	1
7·1	4	1	1	2	5
7·3	2	1	1	—	3
7·5	1	—	—	1	6
7·7	5	—	—	1	9
7·9	19	4	1	5	16
8·1	25	7	13	24	29
8·3	11	9	9	21	35
8·5	14	7	8	7	44
8·7	35	5	8	5	60
8·9	134	32	50	78	69
9·1	162	62	82	147	110
9·3	60	39	36	86	86
9·5	65	19	40	48	77
9·7	120	12	16	41	83
9·9	277	86	125	145	93
10·1	175	90	137	150	69
10·3	49	49	52	60	57
10·5	34	13	16	25	25
10·7	50	5	13	21	14
10·9	80	32	38	47	20
11·1	17	12	25	23	10
11·3	9	2	10	11	3
11·5	3	1	1	2	5
11·7	3	2	—	1	4
11·9	4	5	2	2	2
12·1	—	3	—	2	1
	1,363	498	684	957	937
Corrected estimate of mean	9·523	9·798	9·803	9·687	9·496
Standard deviation	·765	·770	·722	·757	·822
Standard error	·021	·034	·028	·024	·027
Co-efficient of variation	8·029	7·865	7·367	7·812	8·659

FREQUENCY TABLE 6B.—*Tree No. 502.*

Length of Bean.

Mid value mm.	Pickings 2	3	4	5
5·3	—	1	—	—
5·5	—	—	1	—
5·7	—	—	—	—
5·9	1	—	1	2
6·1	1	2	3	3
6·3	4	—	1	—
6·5	5	2	3	—
6·7	6	1	6	1
6·9	14	9	8	4
7·1	24	30	14	8
7·3	56	29	16	14
7·5	48	13	20	7
7·7	33	10	25	5
7·9	73	75	44	27
8·1	73	124	73	41
8·3	101	83	99	26
8·5	75	44	103	16
8·7	61	32	80	11
8·9	99	153	148	52
9·1	63	171	152	62
9·3	68	82	182	37
9·5	33	46	125	21
9·7	16	21	54	13
9·9	43	86	88	27
10·1	13	50	56	37
10·3	15	21	37	8
10·5	11	4	19	4
10·7	6	6	5	5
10·9	3	9	7	5
11·1	3	6	—	3
11·3	3	2	3	—
11·5	—	—	1	1
11·7	—	3	—	—
11·9	—	1	—	2
12·1	—	—	—	1
	951	1,116	1,374	443

Corrected estimate of mean	8·461	8·845	8·980	8·935
Standard deviation	·907	·881	·808	·979
Standard error	·029	·026	·022	·046
Co-efficient of variation	10·719	9·957	8·993	10·960

(ii) *Length.*—To be able to measure within ·02 per cent of the tree mean was considered adequate. From the above tables it is calculated that N = 100 is sufficient for any one picking ($\frac{2 \text{ s.e.}}{\text{mean}}$ is not greater than ·02 of the mean).

Note that the range of bean length from one tree is from 5·3–12·1m.m.

It will be noticed from the tables that Tree N30 which is a Bourbon is a longer bean with the second picking predominating, whereas with Tree F502, a Kent, the peak is at the fourth picking. The difference between the two trees as to length at pickings is probably accounted for by the nature of the flowerings.

(iii) *Width.*—This was measured in groups by shaking through sieves with circular holes as used in the cleaning works.

The sizes of holes are as follows:—

9B	6·875mm.	The A's of commerce.
8	6·750 ,,	
7	6·625 ,,	
6A	6·500 ,,	
5	6·375 ,,	
4	6·250 ,,	
3A	6·125 ,,	
3	6·000 ,,	

with a uniform difference of ·125mm.

FREQUENCY TABLE 7.

Width of Beans. All crop.

Sieves	Tree F502 Pickings				Tree N30 Pickings				
	2	3	4	5	2	3	4	5	6
9B	89	251	300	142	479	146	299	429	344
8	73	106	172	46	230	77	96	119	130
7	59	103	154	23	110	45	40	84	87
6A	90	103	150	34	145	73	67	85	112
5	108	100	189	53	93	60	64	93	118
4	35	39	51	16	27	10	18	29	19
3A	107	103	68	37	86	34	32	47	50
3	75	44	53	25	45	24	19	27	34
Remainder ...	318	284	248	81	196	61	80	161	133
Total ...	954	1,133	1,385	457	1,411	530	715	1,074	997

This is a quick operation so that the whole crop from one tree may be readily taken as the sample.

Similar facts are brought out in this dimension as to time of picking. The Bourbon tree is moreover wider—36 per cent of 9B grade as against the 20 per cent for the Kent's. A large proportion of the beans of both trees are, however, very narrow.

(iv) *Boldness.*—This is a difficult measurement with callipers, but an easy, quick but adequate grouping was achieved by passing the beans through "peaberry" screens.

The sizes are—

Large	more than	4·198mm.
Medium	,,	4·127 ,,
Small	,,	3·921 ,,
Remainder	less than	3·921 ,,

FREQUENCY TABLE 8.

Boldness.

Grade Bars	Tree F502 Pickings				Tree N30 Pickings				
	2	3	4	5	2	3	4	5	6
L	186	274	202	105	169	61	74	148	120
M	76	74	54	12	42	15	25	37	49
S	69	101	63	37	133	46	51	89	78
R	623	684	1,066	303	1,067	408	565	800	750
Total ...	954	1,133	1,385	457	1,411	530	715	1,074	997

In this measurement the whole crop from the tree under examination is taken. The second picking is still the peak for the Bourbon. Kent's in this measurement is superior—19 per cent of the bold beans as against 12 per cent in Bourbon. There are, however, many flat beans in both trees.

(v) *Volume.*—This measurement is only approximate and was obtained by quick successive displacement of water in a graduated cylinder with samples of two hundred beans.

An accurate means of rapidly calculating density must be developed as it is possible that this property (called "flintiness" in the trade) may be correlated with liquoring qualities.

Liquoring.—This is the most important quality to be attained in selection work. Unfortunately it is also the most difficult for there are clearly unaccountable differences in samples prepared in the same way and from the same trees.

The results, for what they are worth, are given below:—

TABLE 9.

Liquoring Tests 1935/36.

Estate	Kind of coffee	Age years	Tree No.	Picking	Cherry weight in ozs.	Points	Means of Estate
A	Bourbon	6	67	14-9-35	83	19	
			186	29-8-35	161	12	
			,,	14-9-35	161	10½	
			294	,,	218	11½	
			37	29-8-35	107	12	
			531	14-9-35	142	14½	
			672	29-8-35	94	13	13·2
B	Bourbon	—	173	8-8-35	298	11½	
			282	,,	311	13½	
			318	,,	327	14½	
			469	,,	367	11	
			689	,,	319	18½	13·8
C	Mixed (Bourbon and Kents)	5	271	31-8-35	406	13	
			,,	9-11-35	406	11	
			,,	27-11-35	406	4	
			298	31-8-35	283	13½	
			354	,,	197	15	11·3
E	Blue Mountain	4	196	31-8-35	440	19½	
			,,	5-9-35	440	*9	
			,,	2-10-35	440	11½	
			258	31-8-35	365	20	
			,,	5-9-35	365	23½	
			287	31-8-35	429	14	
			,,	5-9-35	429	17	
			473	31-8-35	134	15½	
			,,	5-9-35	134	14	
			405	31-8-35	366	15	
			492	,,	576	16½	
			,,	5-9-35	576	14	
			636	31-8-35	447	16½	
			,,	5-9-35	447	18	16·0
F	Kents	9	82	3-9-35	235	19½	
			82	12-9-35	235	18½	
			158	3-9-35	204	16½	
			,,	12-9-35	204	13½	
			425	3-9-35	59	14½	16·5
G	Bourbon	10	122	9-9-35	220	12	
			,,	23-9-35	220	13½	
			130	9-9-35	280	10½	
			,,	23-9-35	280	7	
			,,	23-11-35	280	15	
			146	9-9-35	258	12	

*Possibly an error in labelling.

TABLE 9.—(*contd.*)

Estate	Kind of coffee	Age years	Tree No.	Picking	Cherry weight in ozs.	Points	Means of Estate
G	Bourbon	10	146	23-9-35	258	15½	
			,,	2-10-35	258	16½	
			,,	7-11-35	258	11½	
			156	2-10-35	282	12	12·5
H	Mixed (Bourbon and Kents)	10	39	16-9-35	297	16	
			40	,,	351	16	
			41	,,	397	17½	
			66	,,	318	15	16·1
J	Mixed (Bourbon and Kents)	12	314	26-9-35	326	16	
			,,	18-10-35	326	11	
			,,	5-11-35	326	17	
			401	26-9-35	154	11	
			,,	18-10-35	154	12	
			,,	5-11-35	154	15	
			462	16-9-35	228	10½	
			,,	5-11-35	228	17	
			,,	19-11-35	228	19½	14·3
L	Bourbon	22	593	22-10-35	193	12½	
			,,	6-11-35	193	13½	
			649	8-10-35	270	14½	
			,,	22-10-35	270	17	
			,,	6-11-35	270	13½	
			,,	19-11-35	270	14½	
			667	8-10-35	233	15	
			,,	22-10-35	233	17	
			,,	6-11-35	233	14½	
			,,	18-11-35	233	13½	14·5
M	Bourbon	11	661	16-9-35	122	19	19
N	Bourbon	40	37	27-8-35	227	15	
			67	12-9-35	205	15½	
			,,	28-11-35	205	3½	
			81	27-8-35	296	11½	
			87	19-9-35	261	10	
			228	12-9-35	207	13	12·6
O	Bourbon	10	160	21-8-35	202	10½	
			236	,,	184	9½	10·0
Q	Bourbon	10	53	10-10-35	276	11½	
			,,	24-10-35	276	11½	
			,,	9-11-35	276	11½	
			,,	28-11-35	276	8½	
			138	13-8-35	192	11	
			,,	27-8-35	192	11¾	
			132	10-10-35	179	15½	
			,,	24-10-35	179	14½	

TABLE 9.—(*contd.*)

Estate	Kind of coffee	Age years	Tree No.	Picking	Cherry weight in ozs.	Points	Means of Estate
Q	Bourbon	10	163	10-10-35	250	$11\frac{3}{4}$	
			,,	24-10-35	250	$13\frac{1}{2}$	
			,,	9-11-35	250	$8\frac{1}{2}$	
			212	10-10-35	240	14	
			,,	28-9-35	240	11	11·8
S	Bourbon	15	10	28-9-35	386	8	
			,,	9-11-35	386	$12\frac{1}{2}$	
			,,	28-11-35	386	10	
			16	18-11-35	234	15	
			40	28-9-35	247	12	
			,,	9-11-35	247	13	11·8

Total points possible 33.

COMPARISONS BETWEEN TREES ON THE SAME ESTATE.

(a) *Weight of Bean.*—On Estate N four trees were compared. Differences in weights while not "significant" were suggestive.

TABLE 10A.

Grammes.

Tree No.	30	39	71	197	Picking Means
Picking 3 ...	·168 ...	·163 ...	·174 ...	·166 ...	·16775
,, 4 ...	·170 ...	·173 ...	·168 ...	·179 ...	·17250
,, 5 ...	·168 ...	·167 ...	·173 ...	·186 ...	·17350
,, 6 ...	·165 ...	·173 ...	·173 ...	·178 ...	·17225
Tree means ...	·16775	·16900	·17200	·17725	·17150

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean Square	½ log*
Between pickings	3 ...	·0000785 ...	·0000262 ...	6·7251
Between trees ...	3 ...	·0002145 ...	·0000715 ...	5·2271
Residual	9 ...	·0002350 ...	·0000261 ...	6·7232
Total ...	15 ...	·0005280 ...	— ...	—

Not significant. Trees suggestive.

Similarly for Estate F.

TABLE 10B.

Tree No.	212	267	269	611	Means
Picking †2 ...	·125 ...	·164 ...	·158 ...	·146 ...	·14825
,, 3 ...	·145 ...	·151 ...	·149 ...	·160 ...	·15125
,, 4 ...	·139 ...	·134 ...	·161 ...	·153 ...	·14675
,, 5 ...	·130 ...	·144 ...	·152 ...	·150 ...	·14400
Means ...	·135 ...	·148 ...	·155 ...	·152 ...	·14756

*The figures are half log negative.

†First picking too small for examination.

Analysis of Variance.

Source of variation	D.F.	*Sum of squares	*Mean square	½ log†
Between pickings	3	·00011	·000036	6·8917
Between trees	3	·00097	·000322	5·9804
Residual	9	·00080	·000089	5·3375
Total	15	·00187	—	—

Not significant. Variance for trees suggestive.

On Estate H differences in weights at different pickings were highly significant (P=·01).

TABLE 10C.

Grammes.

Tree No.	19	21	34	88	90	Picking Means
Picking 2	·224	·210	·213	·209	·214	·2140
,, 3	·215	·201	·206	·205	·190	·2034
,, 4	·174	·201	·206	·192	·198	·1942
,, 5	·196	·196	·182	·183	·187	·1888
,, 6	·175	·191	·190	·174	·182	·1824
Tree means	·1968	·1998	·1994	·1926	·1942	·19656

Second picking significantly higher than fourth, fifth and sixth and mean.
Third picking significantly higher than fifth and sixth.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log†
Between pickings	4	·00308616	·00077154	4·4164
Between trees	4	·00019936	·00004984	5·0466
Residual	16	·00132864	·00008304	5·3019
Total	24	·00461416	—	—

Pickings significant by "Z" test for P=·01.
Significant difference=·01329grs.
On Estate D similar results were obtained.

TABLE 10D.

Tree No.	165	197	393	567	S	Means
Picking 1	·124	·143	·131	·146	·147	·1382
,, 2	·138	·139	·136	·155	·196	·1528
,, 3	·163	·136	·152	·158	·181	·1580
,, 4	·178	·186	·152	·169	·185	·1740
,, 5	·167	·165	·159	·202	·171	·1728
Means	·1540	·1538	·1460	·1660	·1760	·15916

Picking 4 significantly higher than pickings 1 and 2.
Picking 5 significantly higher than picking 1.
Random sample significantly higher than trees 165, 197 and 393.
Picking 1 significantly lower than general mean.

*Approximate figures typed. †The figures are half log negative.

Analysis of Variance.

Source of variation	Degrees of freedom	Sum of squares	Mean variance	½ log*
Between pickings ...	4 ...	·004437 ...	·00110925 ...	4·59778
Between trees ...	4 ...	·002795 ...	·00069875 ...	4·36689
Residual	16 ...	·003187 ...	·00019919 ...	5·73938
Total ...	24 ...	·010419 ...	— ...	—

Between pickings variance significant by "Z" for P=·01.
Between trees variance significant by "Z" for P=·05.
Significant difference=·0206grs.

To summarize, neighbouring trees have not varied much as to their mean bean weights at any one picking. There is, however, definite evidence that time of picking has a marked effect.

(b) *Bean Length.*—In this measurement the same results are noted as for weights.

TABLE 11A.—*Estate N.*
Millimetres.

Tree No.	30	39	71	197	Picking Means
Picking 3	9·8 ...	10·1 ...	10·0 ...	10·1 ...	10·000
,, 4	10·0 ...	10·0 ...	9·8 ...	9·8 ...	9·900
,, 5	9·9 ...	10·1 ...	10·1 ...	8·8 ...	9·725
,, 6	9·6 ...	10·2 ...	9·7 ...	9·6 ...	9·775
Tree means	9·825	10·100	9·900	9·575	9·850

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings ...	3 ...	0·185 ...	0·0617 ...	2·6072
Between trees ...	3 ...	0·565 ...	0·1883 ...	1·1651
Residual	9 ...	0·950 ...	0·1056 ...	2·8759
Total ...	15 ...	1·700 ...	— ...	—

Not significant.

TABLE 11B.—*Estate F.*

Tree No.	212	267	269	611	Means
Picking 2 ...	8·7 ...	9·3 ...	9·5 ...	9·3 ...	9·200
,, 3 ...	8·7 ...	8·8 ...	8·8 ...	8·7 ...	8·750
,, 4 ...	9·0 ...	9·1 ...	9·2 ...	9·2 ...	9·125
,, 5 ...	9·0 ...	8·9 ...	8·7 ...	9·0 ...	8·900
Means	8·850 ...	9·025 ...	9·050 ...	9·050 ...	8·994

Second picking significantly longer than picking 3.
Third picking significantly shorter than pickings 2 and 5.
Fourth picking significantly longer than picking 3.

*The figures are half log negative.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean squares	½ log*
Between pickings	3	0·511875	0·170625	1·1157
Between trees	3	0·111875	0·037292	2·3554
Residual error	9	0·345625	0·038403	2·3701
Total	15	0·969375	—	—

Between pickings variance significant by "Z" test for P=·05.
Significant difference 0·339mm.

TABLE 11C.—*Estate H.*

Millimetres.

Tree No.	19	21	34	88	90	Picking Means
Picking 2	10·4	10·0	10·2	9·8	10·1	10·10
,, 3	10·3	10·1	10·1	10·1	9·8	10·08
,, 4	9·8	9·8	9·7	9·6	9·5	9·68
,, 5	9·5	9·8	9·6	9·4	9·6	9·58
,, 6	9·3	9·4	9·7	9·4	9·7	9·50
Tree means	9·86	9·82	9·86	9·66	9·74	9·788

Second picking significantly higher than fourth, fifth and sixth and mean.
Third picking significantly higher than fourth, fifth and sixth and mean.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings	4	1·6024	·4006	1·5426
Between trees	4	0·1504	·0376	2·3596
Residual	16	0·4736	·0296	2·2400
Total	24	2·2264	—	—

Pickings significant by "Z" test for P=·01.
Significant difference ·2509mm.

TABLE 11D.—*Estate D.*

Tree No.	165	197	393	567	S	Means
Picking 1	8·5	8·5	8·9	7·9	9·4	8·64
,, 2	8·2	9·3	8·8	9·5	10·1	9·18
,, 3	9·4	9·7	9·1	8·9	10·0	9·42
,, 4	9·5	9·6	8·9	9·3	9·6	9·38
,, 5	9·0	9·2	9·3	9·7	9·3	9·30
Means	8·92	9·26	9·00	9·06	9·68	9·184

*The figures are half log negative.

Analysis of Variance.

Source of variation	Degrees of freedom	Sum of squares	Mean variance	½ log*
Between pickings ...	4	2·0176	0·5044	1·65780
Between trees	4	1·8536	0·4634	1·61541
Residual	16	2·8424	0·1776	1·13605
Total ...	24	6·7136	—	—

Not significant "pickings" variance suggestive.

Bean Width.—In this characteristic Estate N shows significant differences both for pickings and for individual trees.

TABLE 12A.

Percentage A's (over 6·75m.m.).

Tree No.	30	39	71	197	Picking Means
Picking 3	60·7	53·9	69·9	69·8	63·575
,, 4	57·7	54·9	72·4	69·4	63·600
,, 5	69·5	60·7	72·6	79·4	70·550
,, 6	60·5	58·5	64·5	76·9	65·100
Tree means	62·100	57·000	69·850	73·875	65·70625

Fifth picking significantly higher than third and fourth.

Tree No. 197 significantly higher than 30 and 39 and mean.

Tree No. 71 significantly higher than 30 and 39 but not higher than mean.

Analysis of Variance.

Source of variation	D.F	Sum of squares	Mean square	½ log
Between pickings ...	3	131·2319	43·7440	1·8891
Between trees ...	3	690·8119	230·2706	2·7197
Residual	9	96·3656	10·7073	1·1856
Total ...	15	918·4094	—	—

Pickings significant by "Z" test for P=·05.

Trees significant with P=·01.

Significant difference=5·662.

Estate F.—Once again both tree and picking differences are real.

TABLE 12B.

Tree No.	212	267	269	611	Means
Picking 2	29·2	46·0	50·9	61·1	46·800
,, 3	37·0	47·9	52·9	48·8	46·650
,, 4	50·7	58·6	69·2	59·3	59·450
,, 5	35·3	51·6	68·4	58·9	53·550
Means	38·050	51·025	60·350	57·025	51·6125

Tree 212 significantly lower than all others.

Tree 269 not quite significantly higher than 267. Significant difference= 9·455.

Second and third pickings significantly lower than fourth picking.

Fourth picking significantly higher than second and third.

* The figures are half log negative.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings	3	451·8675	150·6225	2·5073
Between trees	3	1159·7025	386·5675	2·9787
Residual	9	268·7475	29·8608	1·6982
Total	15	1880·3175	—	—

Between pickings significant by P=·05.
Between trees significant by P=·01.

Estate H.—In this case only differences between pickings are significant.

TABLE 12C.

Percentage A's (over 6·75mm.).

Tree No.	19	21	34	88	90	Picking Means
Picking 2	94·2	90·4	90·1	92·4	89·7	91·36
,, 3	92·0	94·3	89·8	87·6	92·9	91·32
,, 4	84·7	90·6	90·8	87·6	86·9	88·12
,, 5	83·3	85·2	88·4	80·1	80·6	83·52
,, 6	82·2	80·6	85·5	82·5	84·0	82·96
Tree means	87·28	88·22	88·92	86·04	86·82	87·456

Second picking significantly higher than fifth and sixth and mean.
Third picking significantly higher than fifth and sixth and mean.
Fourth picking significantly higher than fifth and sixth but not significantly higher than mean.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings	4	331·5936	82·8984	2·2088
Between trees	4	25·8376	6·4594	0·9327
Residual	16	104·1504	6·5094	0·9366
Total	24	461·5816	—	—

Pickings significant by "Z" test for P=·01.
Significant difference=3·721.

Estate D.—The same results have been obtained here as on Estate H except that picking 4 is the best.

TABLE 12D.

Tree No.	165	197	393	567	S	Means
Picking 1	41·3	50·0	52·9	48·2	57·0	49·88
,, 2	58·1	59·3	60·2	71·7	66·5	63·16
,, 3	80·0	52·4	63·3	64·7	72·4	66·56
,, 4	77·1	75·3	66·5	73·9	81·8	74·92
,, 5	79·1	69·6	73·4	85·2	68·4	75·14
Means	67·12	61·32	63·26	68·74	69·22	65·932

First picking significantly lower than all others.
First and second pickings significantly lower than fourth and fifth.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings ...	4 ...	2156·5824 ...	539·1456 ...	3·1448
Between trees ...	4 ...	242·5864 ...	60·6466 ...	2·0525
Residual	16 ...	776·5656 ...	48·5353 ...	1·9411
Total ...	24 ...	3175·7344 ...	— ...	—

Variance for "pickings" significant by "Z" test for P=·01.
Significant difference=10·160.

(d) *Boldness of Bean.*—Once again on Estate N one tree is definitely superior to the others. There is no difference as to pickings.

TABLE 13A.

Percentage over 4·198mm.

Tree No.	30	39	71	197	Picking Means
Picking 3	17·3 ...	15·9 ...	10·3 ...	32·4 ...	18·975
,, 4	15·6 ...	18·4 ...	11·1 ...	25·8 ...	17·725
,, 5	13·5 ...	18·0 ...	8·2 ...	24·1 ...	15·950
,, 6	15·9 ...	16·5 ...	12·9 ...	28·3 ...	18·400
Tree means	15·575	17·200	10·625	27·650	17·7625

Tree No. 197 significantly higher than all others.
Tree No. 71 significantly lower than all others.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings ...	3 ...	20·6525 ...	6·8842 ...	0·9646
Between trees ...	3 ...	615·2325 ...	205·0775 ...	2·6617
Residual	9 ...	41·3925 ...	4·5992 ...	0·7629
Total ...	15 ...	677·2775 ...	— ...	—

Trees significant by "Z" test for P=·01.
Significant difference=3·711.
On Estate F there are no definite differences although those between pickings are suggestive.

TABLE 13B.

Tree No.	212	267	269	611	Picking Means
Picking 2	19·7 ...	24·7 ...	25·7 ...	22·9 ...	23·250
,, 3	25·9 ...	22·8 ...	26·6 ...	51·0 ...	31·575
,, 4	17·8 ...	16·4 ...	20·4 ...	16·4 ...	17·750
,, 5	18·1 ...	18·0 ...	29·5 ...	14·4 ...	20·000
Tree means	20·375	20·475	25·550	26·175	23·144

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings ...	3 ...	440·2919 ...	146·7640 ...	2·4945
Between trees ...	3 ...	119·0669 ...	39·6890 ...	1·8405
Residual	9 ...	552·9406 ...	61·4378 ...	2·0590
Total ...	15 ...	1112·2994 ...	— ...	—

Not significant between pickings suggestive.

On Estate H differences between trees are not definite but those between pickings are highly significant. In this case it is the second picking.

TABLE 13C.

Percentage over 4·198mm.

Tree No.	19	21	34	88	90	Picking Means
Picking 2 ...	43·0 ...	25·3 ...	26·8 ...	25·2 ...	35·6 ...	31·18
,, 3 ...	24·5 ...	16·5 ...	23·1 ...	25·7 ...	27·8 ...	23·52
,, 4 ...	16·2 ...	21·4 ...	17·1 ...	21·8 ...	21·9 ...	19·68
,, 5 ...	16·8 ...	17·8 ...	20·8 ...	18·7 ...	25·9 ...	20·00
,, 6 ...	21·3 ...	19·4 ...	21·7 ...	17·1 ...	19·5 ...	19·80
Tree means	24·36 ...	20·08 ...	21·90 ...	21·70 ...	26·14 ...	22·836

Second picking significantly higher than all others.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings ...	4 ...	486·5536 ...	121·6384 ...	2·4003
Between trees ...	4 ...	115·0056 ...	28·7514 ...	1·6793
Residual	16 ...	304·0184 ...	19·0012 ...	1·4722
Total ...	24 ...	905·5776 ...	— ...	—

Pickings significant by "Z" test for P=·01.

Significant difference=6·357.

On Estate D there are no real differences.

TABLE 13D.

Tree No.	165	197	393	567	S	Means
Picking 1 ...	8·4 ...	14·5 ...	7·4 ...	6·7 ...	10·2 ...	9·44
,, 2 ...	9·2 ...	13·0 ...	13·3 ...	8·5 ...	12·0 ...	11·20
,, 3 ...	18·4 ...	14·2 ...	10·1 ...	11·1 ...	13·0 ...	13·36
,, 4 ...	17·5 ...	12·4 ...	9·8 ...	23·3 ...	15·0 ...	15·60
,, 5 ...	13·5 ...	10·7 ...	12·5 ...	30·3 ...	14·2 ...	16·24
Means ...	13·40 ...	12·96 ...	10·62 ...	15·98 ...	12·88 ...	13·168

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings	4	165·7984	41·4496	1·8622
Between trees	4	72·8984	18·2246	1·4512
Residual	16	388·7576	24·2973	1·5952
Total	24	627·4544	—	—

Not significant.

(e) *Volume of Bean.*—On Estates N and F there are no definite differences either for pickings or trees for volume.

TABLE 14A.—*Estate N.*

Cubic centimetres.

Tree No.	30	39	71	197	Picking Means
Picking 3	·14	·14	·14	·14	·1400
,, 4	·14	·13	·12	·14	·1325
,, 5	·13	·14	·13	·15	·1375
,, 6	·13	·14	·14	·13	·1350
Tree means	·1350	·1375	·1325	·1400	·13625

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings	3	·000125	·0000417	6·9575
Between trees	3	·000125	·0000417	6·9575
Residual	9	·000525	·0000583	5·1250
Total	15	·000775	—	—

Not significant.

TABLE 14B.—*Estate F.*

Tree No.	212	267	269	611	Means
Picking 2	·11	·14	·12	·12	·1225
,, 3	·12	·12	·12	·13	·1225
,, 4	·11	·12	·13	·13	·1225
,, 5	·12	·12	·11	·12	·1175
Means	·115	·125	·120	·125	·12125

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings	3	·000075	·0000250	6·7017
Between trees	3	·000275	·0000917	5·3515
Residual	9	·000625	·0000694	5·2122
Total	15	·000975	—	—

Not significant. Variance for "trees" suggestive.

*The figures are half log negative.

On Estates H and D there are no differences between trees but pickings are highly significant.

TABLE 14C.—*Estate H.*

Cubic centimetres.

Tree No.	19	21	34	88	90	Picking Means
Picking 2	·18	·17	·17	·17	·18	·174
,, 3	·17	·16	·16	·17	·17	·166
,, 4	·14	·16	·16	·15	·16	·154
,, 5	·15	·15	·15	·15	·15	·150
,, 6	·14	·12	·15	·14	·15	·140
Tree means	·156	·152	·158	·156	·162	·1568

Second picking significantly higher than fourth, fifth and sixth and mean.

Third picking significantly higher than fourth, fifth and sixth but not significantly higher than mean.

Fourth picking significantly higher than sixth.

Sixth picking significantly lower than mean.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings	4	·003584	·000896	4·4912
Between trees	4	·000264	·000066	5·1871
Residual	16	·000896	·000056	5·1049
Total	24	·004744	—	—

Pickings significant by "Z" test for P=·01.

Significant difference=0·0109.

TABLE 14D.—*Estate D.*

Tree No.	165	197	393	567	S	Means
Picking 1	·12	·12	·12	·11	·12	·118
,, 2	·12	·11	·12	·11	·18	·128
,, 3	·12	·14	·16	·14	·16	·144
,, 4	·16	·16	·14	·15	·16	·154
,, 5	·15	·15	·14	·17	·16	·154
Means	·134	·136	·136	·136	·156	·1396

Pickings 3, 4 and 5 significantly higher than picking 1.

Pickings 4 and 5 significantly higher than picking 2.

*The figures are half log negative.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean variance	½ log*
Between pickings ...	4 ...	·005176 ...	·001294 ...	4·67504
Between trees ...	4 ...	·001696 ...	·000424 ...	4·11712
Residual	16 ...	·003824 ...	·000239 ...	5·83048
Total ...	24 ...	·010696 ...	— ...	—

Between pickings significant by "Z" test for P=·01.
Significant difference=·0225.

Conclusion on Differences in Bean Characteristics of Neighbouring Trees.

The work described above justifies itself by proving that trees exist which bear beans significantly larger and heavier than their neighbours. The usefulness of the work is enhanced by the fact that trees selected for yield, for example, N197, which has averaged at the rate of 29·4 hundredweights an acre for three years, with little biennial habit, may also be outstandingly good in their bean characteristics. The results indicate the need for this work being extended. This entails the co-operation of planters. Those noticing good yielders of fine beans should, in their own interests, draw our attention to such trees. Within the limits of practical considerations they will be recorded and the beans measured. It must be realized finally that the "selections" must be proved by the performance of their progeny in different districts. This will be commenced in 1938, both rooted cuttings and seed being used.

(C).—Comparisons between Bean Characteristics of Samples from Different Estates.

The next obvious step was to compare adequate samples from the recorded blocks on different estates to see if soil, altitude, etc., had any effects.

Random samples of cherry taken from the whole crop of the recorded blocks, at each picking, were examined. In 1935-36 it was done for four estates only. The results are given below. In no dimensions are the figures significant.

Estate E is young Blue Mountain coffee, F is Kent's and J and L are Bourbon. There is nearly 1,500 feet difference between the altitude of the highest and lowest estates. One would have also said that the soil differed widely in fertility.

Table 15.

(a) *Mean Weight per Bean* (in grs.).

Plot No.	E	F	J	L	Means
Picking 1 ...	0·113 ...	0·178 ...	0·176 ...	0·195 ...	0·16550
,, 2 ...	0·112 ...	0·160 ...	0·172 ...	0·181 ...	0·15625
,, 3 ...	0·210 ...	0·169 ...	0·168 ...	0·188 ...	0·18375
,, 4 ...	0·170 ...	0·178 ...	0·160 ...	0·157 ...	0·16625
Means	0·15125	0·17125	0·16900	0·18025	0·16794

*The figures are half log negative.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean variance	½ log
Between pickings	3	0·0015817	·0005272	4·226055
Between plots	3	0·0017687	·0005896	4·28194
Residual	9	0·0064066	·0007118	4·37617
Total	15	0·0097570	—	—

Not significant.

(b) *Mean Length of Bean* (in mm.).

Plot No.	E	F	J	L	Means
Picking 1	9·3	9·6	9·6	9·7	9·550
,, 2	9·1	9·1	9·6	9·1	9·225
,, 3	10·1	9·3	9·8	9·6	9·700
,, 4	9·0	9·6	9·2	9·2	9·250
Means	9·375	9·400	9·550	9·400	9·43125

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean variance	½ log*
Between pickings	3	0·646875	0·2156250	1·23289
Between plots	3	0·076875	0·0256250	2·16791
Residual	9	0·730625	0·0811805	2·74446
Total	15	1·454375	—	—

Not significant.

(c) *Width of Bean.*

Percentage A's (over 6·75mm.).

Plot No.	E	F	J	L	Means
Picking 1	11·6	73·6	65·6	86·9	59·425
,, 2	9·3	62·2	65·4	81·9	54·700
,, 3	85·9	69·1	61·1	75·7	72·950
,, 4	79·0	68·2	49·0	50·3	61·625
Plot means	46·450	68·275	60·275	73·700	62·175

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings	3	719·365	239·788	2·7399
Between plots	3	1683·685	561·228	3·1651
Residual	9	5532·500	614·722	3·2105
Total	15	7935·550	—	—

Not significant.

*The figures are half log negative.

(d) *Boldness of Bean.*

Percentage over 4·198mm. (wide bars).

Plot No.	E	F	J	L	Means
Picking 1	—	13·4	20·2	13·8	11·850
,, 2	7·1	14·7	17·9	10·4	12·525
,, 3	22·1	15·1	16·6	15·6	17·350
,, 4	11·0	14·1	12·3	8·3	11·425
Plot means	10·050	14·325	16·750	12·025	13·2875

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings	3	90·4825	30·1608	1·7032
Between trees	3	100·5625	33·5208	1·7561
Residual	9	232·4725	25·8303	1·6393
Total	15	423·5175	—	—

Not significant.

(e) *Mean Volume per Bean.*

Plot No.	E	F	J	L	Means
Picking 1	0·11	0·16	0·16	0·17	0·1500
,, 2	0·09	0·14	0·15	0·16	0·1350
,, 3	0·19	0·14	0·14	0·17	0·1600
,, 4	0·15	0·16	0·14	0·13	0·1450
Means	0·1350	0·1500	0·1475	0·1575	0·1475

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean variance	½ log*
Between pickings	3	0·00130	0·0004333	4·12799
Between trees	3	0·00105	0·0003500	4·02121
Residual error	9	0·00635	0·0007055	4·37173
Total	15	0·00870	—	—

Not significant.

In 1936-37 ten estates have been compared. This year there were very clear differences between estates. Higher estates were in general best.

*The figures are half log negative.

TABLE 16.—*Plot Samples 1936-37.*

(a) *Mean Weight of Bean* (Grammes).

	1	2	3	4	5	Total
Estate C ...	·144	·150	·162	·147	·163	·1532
,, E ...	·184	·176	·178	·184	·189	·1822
,, F ...	·145	·177	·160	·163	·175	·1640
,, H ...	·196	·201	·191	·191	·167	·1892
,, I ...	·166	·187	·191	·183	·172	·1798
,, J ...	·185	·198	·166	·166	·169	·1768
,, K ...	·189	·163	·153	·143	·144	·1584
,, L ...	·204	·197	·185	·175	·179	·1880
,, M ...	·174	·195	·173	·179	·163	·1768
,, N ...	·185	·165	·174	·181	·173	·1756
Means ...	·1772	·1809	·1733	·1712	·1694	·1744

E, H, L significantly higher than C, F and K.

I, J, M and N significantly higher than C and K.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings ...	4	·0008654	·00021635	5·7806
Between plots ...	9	·0066028	·00073364	4·3912
Residual	36	·0049678	·00013799	5·5559
Total ...	49	·0124360	—	—

Plots significant by "Z" test for P=·01.

Significant difference=·0171grs.

With length there is a tendency for higher estates to be top but the Bourbon and Blue Mountain coffee is longer than the Kent's.

(b) *Mean Length of Bean* (Millimetres).

	1	2	3	4	5	Total
Estates C ...	8·7	8·7	9·2	8·6	9·1	8·86
,, E ...	9·6	9·7	9·8	9·7	10·1	9·78
,, F ...	9·4	9·7	9·5	9·0	9·2	9·36
,, H ...	9·9	10·0	10·1	9·9	9·6	9·90
,, I ...	9·5	9·9	9·9	9·7	9·5	9·70
,, J ...	9·7	10·3	9·4	9·4	9·8	9·72
,, K ...	9·8	9·1	8·7	8·8	8·7	9·02
,, L ...	10·2	9·8	9·7	9·5	9·7	9·78
,, M ...	9·4	9·8	9·8	9·9	9·6	9·70
,, N ...	9·8	9·8	10·0	9·7	9·7	9·80
Means ...	9·60	9·68	9·61	9·42	9·50	9·562

E, H, L and N significantly higher than C, F and K.

I, J and M significantly higher than C and K.

*The figures are half log negative.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings	4	·4168	·10420	2·8692
Between plots	9	5·7818	·6424	1·7787
Residual	36	2·5192	·06998	2·6702
Total	49	8·7178	—	—

Plots significant by "Z" test for P=·01.
Significant difference=·386mm.

In width the same tendencies occurred but in this measurement pickings are also significant.

(c) *Width of Bean.*

Percentage A's (over 6·76mm.).

	1	2	3	4	5	Total
Estate C	67·0	65·5	65·4	68·1	79·0	69·00
,, E	82·9	88·9	91·0	91·1	82·4	87·26
,, F	47·8	78·2	53·2	60·7	66·2	61·22
,, H	86·3	89·4	85·2	87·6	64·7	82·64
,, I	81·4	89·4	85·7	81·3	75·9	82·74
,, J	85·8	90·3	76·7	74·9	64·7	78·48
,, K	87·7	89·0	89·1	61·8	61·2	77·76
,, L	91·9	88·5	88·9	83·9	78·8	86·40
,, M	68·5	85·4	76·9	69·8	65·6	73·24
,, N	76·0	54·2	69·7	70·9	64·3	67·02
Means	77·53	81·88	78·18	75·01	70·28	76·576

L and E significantly higher than C, F, M and N.
H and I significantly higher than C, F and N.
F significantly lower than all except M.
Second picking significantly higher than fifth.
Third picking significantly higher than fifth.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings	4	737·0732	184·2683	2·6083
Between plots	9	3430·5072	381·1675	2·9716
Residual	36	2456·0108	68·2225	2·1106
Total	49	6623·5912	—	—

Pickings significant by "Z" test for P=·05. Plots by "Z" test for P=·01.
Significant difference for plots=12·05.
Significant difference for pickings=7·76mm.

In boldness both estates and pickings have significant differences. Blue Mountain retains its place but Bourbon is flatter and Kent's bolder. This confirms individual tree comparison.

*The figures are half log negative.

(d) *Boldness of Bean.*

Percentage over 4·198mm. (wide bars).

	1	2	3	4	5	Total
Estate C ...	7·7	11·8	7·7	11·7	15·0	10·78
,, E ...	17·5	22·2	11·6	14·7	20·9	17·38
,, F ...	13·3	19·9	17·5	15·9	22·8	17·88
,, H ...	16·3	18·6	17·8	14·7	15·1	16·50
,, I ...	15·6	15·2	17·2	17·7	29·5	19·04
,, J ...	22·8	21·4	10·2	8·9	12·6	15·18
,, K ...	15·7	10·0	7·9	8·7	9·0	10·26
,, L ...	21·2	19·1	17·1	12·5	14·9	16·96
,, M ...	13·9	27·7	11·4	11·6	12·6	15·44
,, N ...	10·8	7·8	7·7	14·2	8·5	9·80
Means ...	15·48	17·37	12·61	13·06	16·09	14·922

E, F, I and L significantly higher than C, K and N.
H significantly higher than K and N.
Second picking significantly higher than third and fourth.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log
Between pickings ...	4	164·8068	41·2017	1·8592
Between plots ...	9	519·2658	57·6962	2·0276
Residual	36	631·8132	17·5504	1·4325
Total ...	49	1315·8858	—	—

Pickings and plots significant by "Z" test for P=·05.
Significant difference for plots=6·11.
Significant difference for pickings=3·94.

With volume pickings are not different but Blue Mountain is definitely larger than the others.

(e) *Mean Volume of Bean* (Cubic Centimetres).

	1	2	3	4	5	Total
Estate C	·12	·12	·13	·13	·14	·128
,, E	·15	·17	·16	·15	·16	·158
,, F ...	·11	·14	·12	·13	·12	·124
,, H ...	·14	·16	·14	·16	·13	·146
,, I ...	·14	·15	·14	·14	·14	·140
,, J ...	·14	·16	·13	·13	·14	·140
,, K ...	·15	·13	·13	·12	·12	·130
,, L ...	·16	·16	·15	·14	·14	·150
,, M ...	·14	·16	·15	·14	·14	·146
,, N ...	·18	·13	·14	·14	·14	·146
Means	·143	·148	·139	·138	·137	·1410

E significantly higher than C, F, J and K.
L significantly higher than C, F and K.
H, M and N significantly higher than C and F.

Analysis of Variance.

Source of variation	D.F.	Sum of squares	Mean square	½ log*
Between pickings ...	4	·00082	·000205	5·7537
Between plots	9	·00513	·000570	4·2651
Residual	36	·00450	·000125	5·5064
Total ...	49	·01045	—	—

Plots significant by "Z" test for P=·01.

Significant difference=·017c.c.

On all counts the Blue Mountain is the largest and heaviest bean. Bourbon is characterized by being longer and flatter as compared with Kent's, which is shorter and bolder.

It is not possible to conclude from the above work that any variety is superior. The difference may be due to environment. Only varietal experiments will give full data.

Correlations of Bean Characteristics.

It was desired to find out whether any one measurement would be sufficient to characterize the beans of any one tree.

By means of working out the correlation co-efficient (r) on samples of beans from individual trees it has been shown that:—

1. Heavy yielders do *not* necessarily give light beans r=+·243 between yield and weight.
   "r" would approach minus unity if it were pronouncedly so.
2. Heavy yielders do *not* necessarily give small beans r=+·114 between yield and volume.
   There is in fact a slight tendency for good yielders to give heavier and larger beans.
   The following correlation co-efficients are all calculated on one picking from the same tree.

Tree H66 Bourbon (from a Wachagga holding).

Mean weight	...	·216 grams.
,, length	...	10·10mm.
,, volume	...	·190c.c.

Yield of Cherry in Ounces.

1934	... ...	225
1935	... ...	318
1936	... ...	255
Mean	... ...	266

Equivalent in hundredweights clean coffee per acre more than 15, average for three years.

3. Long beans are *not* necessarily flat beans r=+·018 between length and boldness.
4. Long beans are *not* necessarily narrow beans r=+·025.
5. Long beans are generally heavy beans r=+·731.
6. Wide beans have a certain amount of positive correlation with weight r=+·489.

*The figures are half log negative.

7. Flat beans are usually lighter beans r=+·654 between boldness and weight.

8. Width and boldness of bean is little correlated r=+·213.

That is to say, heavy yielders are just as likely to have large heavy beans as are their poor yielding neighbours. It has not yet been possible to tackle the important question of correlation between weight and volume.

S. M. Gilbert
Chief Scientific Officer

SECTION IV.—The Vegetative Propagation of Coffea spp.

Introduction.—Work on the vegetative propagation of *Coffea* was commenced at the Coffee Research and Experimental Station in 1934, when over a thousand young *Coffea arabica* plants of various types and varieties were budded and grafted. A few *Coffea robusta* were also budded with scions from *C. arabica* and vice versa, but this was limited by the amount of *C. robusta* plants on the station at that time.

Methods of Propagation.—The more intensive investigations on the various methods of vegetative propagation of *Coffea* spp. were commenced in May 1935, when the different ways of propagation of plants in general were considered in their application to *C. arabica*.

The rooting of cuttings, layering, marcotting, budding and grafting were all tried but owing to the limited amount of material procurable, especially clonal material, little definitely comparable work on these lines has been possible up to the present.

The first object therefore was to find the quickest methods by which clonal material might be propagated. After trials of the various methods mentioned, cuttings seemed to give promise of the quickest results so this method was concentrated upon, leaving the other methods as alternatives to be more thoroughly investigated as sufficient material became available.

Propagators.—Working along the lines used by the Cacao Research Scheme, Trinidad, concrete propagating cases were constructed(1). The cases were put two feet in the ground to help to retain the moist atmosphere needed.

The sizes of the first propagating cases were as follows:—

Three feet by three and half feet, the top of the cases sloping outwards at an angle of one in nine. Hinged lids were fixed and glass inserted. The glass was then covered with a single layer of Americani (cheese cloth), and canvas blinds (which could be rolled up when no sun was on the cases) were erected on angle iron four feet above the top of the cases. No artificial heat was required.

Types of Cuttings.—In the knowledge(2) that material taken from laterals would normally only give lateral growth, cuttings have been mainly taken from the terminal stem of the trees to be propagated. Laterals have been taken for further observation, but have proved rather more difficult to root than material taken from the terminal stem and, so far, as expected, have only given lateral growth. Hard, soft, root and leaf cuttings were obtained from

(1) Prop. of Cacao. Fourth and fifth Annual Report of Cacao Research.
(2) Prop. of Coffee, Gillett, *East African Agricultural Research Journal.*

suckers from mature, and young, stumped trees, from layered trees which were of necessity young, and from adventitious suckers from mature trees in their normal habit of growth. These cuttings were inserted in the different rooting materials and successful rooting in varying degrees of success was obtained in all materials.

Rooting Materials.—Various rooting materials were tried, including a fine quartz sand, leaf-mould, fine coconut fibre and mixtures of sand and leaf-mould and sand and coconut fibre. Recently peat moss litter has been tried and also a mixture of peat moss and sand, but further work has yet to be done before definite conclusions can be reached on the suitability of these materials. In passing it may be said that callusing of cuttings is quicker in a mixture of peat moss and sand than in any other material. The most successful rooting both in time and quantity was obtained in a mixture of 50 per cent sand and 50 per cent leaf-mould. Rooting took place in the other materials but not in sufficient quantities and speed to justify further work at the time. The roots which were obtained were thin, and in pure sand a certain amount of water logging was found causing the cuttings to rot.

Hard-wood Cuttings.—The only hard cuttings obtainable when the work was commenced were from the terminal stems of mature trees in their normal habit of growth. This material, taken from necessity from the inside of the tree, where little light could penetrate, was sappy, and the internodes very elongated. It was obvious that this material was not the most suitable for rooting but it was found that these cuttings would root both with the leaves removed and with the leaves left on, but the percentage of rooting and the time taken to root was small compared with cuttings taken from softer wood. Another point against hard-wood cuttings is that so far comparatively few rooted cuttings have survived transplanting. A loss of nearly 50 per cent was recorded on transplanting into fibre pots into similar material as that in which they were induced to root with the addition of a little soil. Of those which survived transplanting, a further loss was recorded when planted out in field conditions.

It is considered that the reason for these losses is that the first roots of the hard wooded cuttings are usually only two or three in number and although these are normally strong and soon develop fibrous roots the root system is not sufficiently advanced to keep the plants going in their critical period (i.e. the time of transplanting). It is not possible to wait until more roots develop before transplanting as the first roots have developed too much for transplanting without injury.

Further trials have been made and in each case the percentage of success has not been sufficient to justify further work until sufficient clonal material has been obtained for other more important experiments.

Soft-wood Cuttings.—This type of cutting, as in Cacao, has been found the most successful up to the present. Rooting up to 100 per cent has been obtained according to the type of cuttings and the variety of *Coffea* from which the cuttings were taken. Soft-wood cuttings have rooted in fourteen days but the average time needed for rooting under these conditions is from four to six weeks. This depends upon the season, for no matter what precautions are taken it has been found impossible to keep the propagating cases at the same temperature and humidity in the hot dry season and the cold wet season. The best season for rooting seems to be in the cool season towards the end of the rains.

In *Coffea arabica* the Maragogipe variety and its hybrids have shown the highest percentage of rooting and are the quickest.

Best Type of Soft Cuttings.—Cuttings from unshaded plants where the internodes are short have proved most successful. Cuttings taken from heavily shaded plants have shown a tendency to rot in the propagating cases before callus is formed.

While the soft cutting with three to four nodes has been found the most successful, those from shaded plants are normally found to have flat nodes and internodes down to the fourth or fifth node and this type of cutting, although making callus quicker than cuttings from unshaded plants, frequently rots off before rooting commences. The occurrence of these flat internodes seems to vary with the intensity of the shade under which the suckers taken as cuttings are growing, those from lighter shade having two or three flat internodes, unshaded plants normally giving suckers with wood of circular shape.

Experiments have been made by cutting above, midway between and just below the node, ring-barking above, and ring-barking below the bottom node, splitting above the lowest node and keeping the split open by insertion of a small pebble or stick, slanting single cuts, horizontal cuts, and two or three cuts making the base of the cutting roughly semi-spherical have all been tried to see if any method has any advantage over the others, but there seems little to choose between them. If any, the last mentioned is slightly better than the others in view of the fact that when making a number of cuttings, especially when done by a native, the knife becomes tainted and unless cleaned leaves a black stain on the cut which is not found in a number of small cuts.

Trials have been made in removing all but the terminal leaves, removing half of each leaf with the exception of the terminal pair, and leaving the cutting in full leaf. Cuttings rot much quicker when all the leaves are removed, but there is little difference in the other two ways as long as the amount of leafage on the cutting is proportionate to its stem. It has been found beneficial to remove any primaries from the stem of the cutting for these wilt first and appear to affect the rest of the cutting.

As the most suitable type of soft cuttings appears to be from four to six inches long, laterals are rarely found, and only in cases where it is impossible to get the shorter, more suitable cutting is it necessary to remove the primaries.

Callus Formation.—Callus has normally been found from one to three weeks after insertion, but it is rare for roots to be produced until a complete ring of callus is formed on the base of the cutting. So far roots have only been obtained from the callus. In many cases, but mostly in hard-wood cuttings, a large amount of callus has been formed, sufficient to cover completely the base of the cutting. In these cases "paring" the callus has been tried but this does not seem to hasten rooting as in some other plants.

Moisture.—It has been found that a saturated atmosphere is necessary in the propagating cases. This is created by a mist spray morning and evening. Further watering of the rooting material has not proved necessary, being "watered in" thoroughly before the insertion of the cuttings which proves sufficient with the mist spray until the cuttings root.

Temperature.—As far as is possible the propagating cases are kept at an even temperature by the means of adjustable shade during the day-time. The heat conserved during the day-time has proved sufficient for the night. Bottom heat, supplied in the shape of Dietz lamps as used in Kenya has not been

successful and apparently artificial heat is unnecessary as the most successful time of the year in rooting the cuttings has been in the cool season.

Ventilation.—Sufficient ventilation to the propagating cases is given when the cases are opened morning and evening. In addition to this, grooves were made in the top of the concrete wall of the propagating cases as an outlet for any surplus moisture. A moderate amount of air is able to pass into the cases by this means.

Methods of Procuring Cuttings.—Various methods have been tried in an endeavour to find a way in which the maximum amount of cuttings may be obtained in the shortest time. Up to the present removal of all primaries and pegging down the main stem horizontal with the ground has given the best results. This is only possible in young plants. Older plants have been cut back to half their normal height and all primaries removed and have produced a considerable amount of suckers to be taken as cuttings.

Stumping of old and young plants has been tried, but has not given comparable results either in quantity or speed.

Unfortunately it is not always possible to remove the primaries from plants from which clonal material is required and it has been necessary to use adventitious suckers as cuttings. These, as said before, do not make really suitable cuttings but have to be used when the material is required.

After Treatment of Rooted Cuttings.—It has been found that the best method of "hardening off" rooted cuttings is to transplant the cuttings into pots of banana fibre or bamboo when the roots are from one to three inches long. They are then potted up into a medium similar to that in which rooting has taken place with a small percentage of ordinary soil added and the pots put into the propagating frame or greenhouse. Once the plants have become established they are then taken out and put under shade until they are ready for planting out in field conditions.

Root Cuttings.—These have been inserted into the various rooting materials tried at various times but have rotted off before any sign of shooting.

Leaf Cuttings.—These were tried both in the propagating cases and on blotting paper and on fibre in Petrie dishes but with no success. It was not anticipated that this method would be successful for as a general rule only plants with leaves which may be termed fleshy are suitable for leaf cuttings.

Leaf Buds.—Leaves cut from the trees with the shoot bud attached were inserted into materials in the propagating cases but the leaves rotted before callus was formed on the bud.

Layering.—A certain number of seedlings have at various times been layered and both hard and soft wooded suckers etiolated with sand, with leaf-mould and with ordinary soil. Suckers which were ring-barked and in other cases split, also suckers left normal, have rooted from hard-wood. Soft-wood suckers have not rooted but have later grown into hard-wood and rooted. The great disadvantage of this method of propagating is its slowness, rooting rarely taking place in less than eight to ten months.

Ring-barked and split suckers have formed callus but these methods appear to have little effect on rooting. In general, the roots have emerged from the main stem which was layered, making another great disadvantage, for cutting the main stem to procure the rooted suckers effectively stops further suckers from emerging from that point and when a quantity of material is needed this method is extravagant.

Marcotting.—The marcotting of both terminal shoots and laterals has been tried but with little success.

Budding and Grafting.—So far all budding and grafting has been done using seedlings as stocks. Sufficient clonal material to commence definite experiments on the compatabilities of the various stocks and scions is not yet available but a certain amount of budding and grafting has been done with fair success.

Budding.—Only buds from upright growth are suitable, buds taken from laterals consistently giving lateral growth. The T and inverted T methods have been used with such success that the more intricate methods such as shield, ring-budding, etc., have not been considered necessary. The most suitable type of bud so far has been the one in which the eye is just breaking, that is, the actual bud showing green. It is usually possible to tell definitely if the bud has "taken" after two months. It is unusual for the actual bud to begin to shoot until three or four months after the budding operation has taken place. Once the bud begins to grow, growth is rapid and the method generally used has been to cut the top of the plant back when the shoot breaks and to cut it back to the bud when the scion is about six inches to a foot long. Flowering and fruiting generally take place two to two and a half years after the plant is budded, according to the time of year when the budding took place.

The unions of all buds on to their scions have so far been quite satisfactory and at the end of two and a half to three years are quite unnoticeable.

One important fact about budding is that it is apparently possible to perform the operation at any time of the year with good chances of success. This is attributed to the fact that the shade of the branches left on above the bud give protection against sun and rain and the plant is still able to make food, whereas with grafts where the terminal stem is cut and all leaves and branches removed no photosynthesis takes place. Another point in favour of budding is that where the bud fails another bud can be inserted on to another portion of the stem. On the other hand, when grafting, the stock is cut and should the graft fail, the stock has to be cut nearer the ground level or allowed to sucker and the sucker grafted, making it a lengthy business. These remarks do not apply to grafting by approach (inarching). This method of propagation has not been used so far as by it only one scion plant can be used for each stock. The most suitable height for insertion of the bud has proved to be about nine inches to a foot from ground level, lower and higher buds than this proving unsatisfactory.

Up to the present the results of the trials on grafting *versus* budding go to prove grafting is the more successful but this is mainly attributed to the fact that most of the budding and grafting on the station is now done by natives. Budding is a more delicate operation than grafting, in that there is only a small portion of the bud which can be held in the fingers, whereas the scion on a graft is easily held without needing to put the fingers near the place where the union between the stock and scion is to be made.

Grafting.—As in regard to budding all grafts so far made have had seedlings as stocks. No definitely comparable experiments have been possible owing to the lack of clonal material. When grafts were first tried little success was obtained. This was attributed to various reasons, the main being the fact that grafting was done at the beginning of the hot dry season. Later, however, grafting proved successful enough to justify experiments in grafting older trees.

It has been found necessary to protect all grafts made with paper cones previously dipped in wax to make them air and water tight, and to erect artificial shade of grass or palm leaves above the grafts. Moisture at the roots has been proved essential and in the dry season constant watering is necessary. Grafting tape has been used but the most successful method has been to use raffia only with no grafting wax. Grafting wax or tape is probably necessary at certain times of the year but this has yet to be definitely proved.

In grafting on to seedlings of one to two years old grafts have been successful in cleft, saddle, side, notch and rind grafting. Up to ninety per cent "takes" have been obtained in all types, there being little to choose at present. The most suitable type for use under field conditions is yet to be noted.

Rind grafting on to mature stumped trees has not been successful and only a small percentage of successful grafts on to the suckers of stumped trees has been obtained. It is obvious that some modifications of the technique of these types of grafting will have to be used in field practice. Grafting on to stumped trees has only been done in the dry season, work in other directions on the station having made it impossible to graft in the field at the best time so far ascertained, which is just at the end of the dry season or the beginning of the rains.

Grafting and Budding on to Cuttings.—Unrooted cuttings of citrus have been grafted with success([3]) and also budded([4]) and these methods have been applied to *Coffea*. Hard and soft cuttings of various types have been grafted and budded. Success has been obtained in both grafting and budding, the percentage of "takes" being good. In the case of grafts callus formed quickly, making rapid union between the stock and scion. Budding at first proved difficult, the bud wood rooting before union took place. It was later successful by using waxed tape as a protection, and the buds "shot" in a remarkably short time.

The great drawback in this method of grafting and budding has been the rooting of the hard-wood cutting used as the stock. Rooting as mentioned before is slow, callus forming quickly but rooting taking up to six months or more. The shoots of the scions have grown rapidly in the close atmosphere of the propagating cases and generally have become elongated and chlorotic and rotted off before cuttings used as the stocks have rooted. Until rooting technique of hard-wood cuttings is improved or rooting hastened by artificial means, such as hormone substances([5]) this method of grafting and budding is useless on a large scale. Once quick rooting is obtained it should be a quick and profitable method of propagation of clonal material.

Pests and Diseases in Propagating Cases.—Various pests have at times proved troublesome in the propagating cases. An outbreak of thrips (*Physothrips xanthoceros*, Hood) on one occasion caused a little damage but all infected cuttings were dipped in a nicotine solution and no further trouble occurred.

Green fly (*Aphis* spp.) have at various times gained entry to the cases but again dipping in nicotine solution proved successful in getting rid of the pest.

Leaf miner (*Leucoptera* spp.) is troublesome at certain times of the year and it has been necessary to remove all infected leaves to the detriment of the cuttings. Recent investigation by the Entomologist show that the parasites

([3]) *Hilgardia*, 6, No. 5, October 1931.
([4]) *Tropical Agriculturist*, LXXXVII, No. 5, November 1936.
([5]) Boyce Thompson Institute, VIII, No. 1 of 1936 (Effect of growth substances on the rooting response of cuttings).

which in normal conditions feed on the leaf miner escape from the propagating cases leaving the miner to damage the leaves without restraint. Experiments with pyrethrum dust seem to point to the fact that the insect may be controlled in this way without damage to the cuttings.

Green scale (*Lecanium viride*) has been found on the cuttings but is easily controlled by hand cleaning.

Diseases.—Recently a serious disease has been encountered in the propagating cases. It is a type of "damping-off" (*Rhyzoctonia* spp.) but not to be confused with the common damping-off which is caused by bacteria. The spread of the disease is rapid and in a day or two a whole case of cuttings may rot off. Investigations by the Plant Pathologist determined the fungus and on his suggestion injected cases were watered with Cheshunt compound and the spread of the disease has been checked. A close watch will be kept in the future and at any sign of the fungus severe measures will be taken. The propagating cases are now being periodically watered with Cheshunt compound as a precautionary measure.

Summary.—Experience so far gained goes to show that soft-wood cuttings are more suitable than hard-wood cuttings both in rooting capacity and in after treatment.

Sand mixed with leaf-mould or with peat moss gives better rooting than pure sand or other materials tried. Propagating cases are necessary to obtain a practical percentage of rooting of cuttings. Materials for propagation of clones is obtained most quickly by pegging down terminal stems of young plants. Layering and marcotting are not practical methods of propagating.

Budding is superior to grafting from the fact that it may be done at any period of the year and is generally a more practical method.

C. B. Gibbins
Agricultural Assistant

Lyamungu, 31st March 1937

SECTION V.—Improvement of Growing Conditions.

EXPERIMENTS.

(a) *General Considerations.*—Yield and other studies have been continued on individual trees mostly in blocks of from seven to eight hundred trees. These blocks cover such a diversity of districts embracing widely different coffees, soils, altitudes, climates and cultural treatments that they may be accepted as a fair sample of the conditions under which *Coffea arabica* is grown in Tanganyika Territory.

Table 17 sets out the important statistical constants for three years records. No comments are necessary to stress the extreme variability of the material on which work has to be done.

Table 17.

Estate	Year	Number of trees	Mean yield in ounces of cherry per tree	Standard deviation	Coefficient of variation percentage
A	1934/5	593	13	18·9	148·6
	1935/6	593	50	44·8	89·6
	1936/7	644	31	31·51	101·2
B	1934/5	780	41	38·12	92·7
	1935/6	780	205	99·19	48·3
	1936/7	780	133	86·09	64·9
C	1934/5	812	131	92·60	70·7
	1935/6	812	70	70·71	101·6
	1936/7	812	48	51·86	107·2
D	1934/5	780	47	30·30	65·1
	1935/6	780	78	34·60	44·2
	1936/7	780	44	52·84	120·6
E	1934/5	780	21	17·26	81·4
	1935/6	780	269	125·47	46·5
	1936/7	780	143	96·47	67·6
F	1934/5	780	120	91·10	75·7
	1935/6	780	140	99·06	70·7
	1936/7	780	108	94·37	87·1
G	1934/5	246	103	94·64	91·7
	1935/6	246	144	98·42	68·4
	1936/7	246	43	50·48	117·0
H	1934/5	255	228	173·13	75·8
	1935/6	255	66	68·44	102·4
	1936/7	255	127	95·70	75·3
I	1934/5	517	186	134·51	72·2
	1935/6	517	35	44·10	125·7
	1936/7	517	141	87·38	62·0

Estate	Year	Number of trees	Mean yield in ounces of cherry per tree	Standard deviation	Coefficient of variation percentage
J	1934/5	797	145	123·95	85·4
	1935/6	797	56	65·53	116·2
	1936/7	390	82	73·95	90·6
K	1934/5	777	136	106·01	77·8
	1935/6	777	crop failed	—	—
	1936/7	777	80	58·87	73·2
L	1934/5	780	123	94·90	76·8
	1935/6	780	117	75·10	64·3
	1936/7	780	56	67·19	120·4
M	1934/5	803	328	126·96	38·7
	1935/6	803	24	35·07	143·4
	1936/7	803	129	66·17	51·4
N	1934/5	241	417	213·50	51·2
	1935/6	241	64	81·76	128·2
	1936/7	241	199	159·28	80·2
O	1934/5	780	5	7·50	156·4
	1935/6	780	65	52·26	80·5
	1936/7	780	19	20·73	112·0
P	1934/5	384	143	104·50	73·0
	1935/6	884	231	125·04	54·1
	1936/7	384	87	103·98	119·9
Q	1934/5	Not recorded		—	—
	1935/6	319	96	78·31	81·82
	1936/7	319	53	64·06	120·0
R	1934/5	Not recorded		—	—
	1935/6	100	196	198·19	101·2
	1936/7	100	202	180·31	89·2
S	1934/5	Not recorded		—	—
	1935/6	118	89	93·35	104·6
	1936/7	118	crop failed	—	—
T	1934/5	Not recorded		—	—
	1935/6	684	75	41·13	54·8
	1936/7	684	15	15·79	107·9

Table 18 gives the results converted to yield of clean coffee per acre. The conversion takes into account the actual amount of clean coffee obtained from random samples of each block at each picking and of the spacing of the trees.

TABLE 18.

Yield of Clean Coffee per Acre of all Uniformity Trial Plots.

(Three years 1934-36).

Plot	1934-5	1935-6	1936-7	Average for three years
A	2·0	7·9	6·9	5·6
B	1·2	7·6	7·7	5·5
C	5·7	2·8	2·2	3·6
D	3·1	5·1	2·9	3·7
E	0·9	11·2	7·8	6·6
F	4·8	5·7	4·2	4·9
G	6·0	8·3	2·6	5·6
H	19·0	3·7	7·1	9·9
I	10·9	1·5	7·4	6·6
J	4·2	1·5	2·9	2·9
K	7·5	crop failed	4·8	4·1
L	9·9	8·3	3·7	7·3
M	8·9	0·6	5·4	4·9
N	22·8	3·3	11·9	12·7
O	0·2	4·2	0·8	1·7
P	5·5	8·4	3·2	5·7
Q	not recorded	7·3	4·5	5·9
R	,,	12·7	13·5	13·1
S	,,	3·8	crop failed	1·9
T	,,	2·4	0·5	1·4

Average of all estates for three years 5·7 hundredweights an acre.

1934-5 *Frequency Table.—Ounces of Cherry for three years all estates,* Table 19

Frequency class in ounces	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q *	R *	S *	T *	Totals	Percentage
0–50	21	25	40	4	209	173	207	35	81	185	171	386	421	557	734	689	–	–	–	–	3,938	42·09
50–100	12	18	30	11	99	141	169	78	59	144	91	140	274	31	1	55	–	–	–	–	1,353	14·46
100–150	10	37	60	11	83	121	148	70	35	145	115	34	31	5	1	–	–	–	–	–	906	9·68
150–200	11	38	61	26	74	115	105	61	19	109	117	11	3	–	–	–	–	–	–	–	750	8·02
200–250	8	77	82	24	53	65	78	60	12	111	83	–	–	–	–	–	–	–	–	–	653	6·98
250–300	14	96	66	30	48	52	43	22	10	47	60	–	–	–	–	–	–	–	–	–	488	5·22
300–350	22	99	51	25	45	31	16	12	7	11	25	–	–	–	–	–	–	–	–	–	344	3·68
350–400	14	129	41	29	30	14	5	14	4	8	17	–	–	–	–	–	–	–	–	–	305	3·26
400–450	23	117	32	25	21	9	4	2	3	2	2	–	–	–	–	–	–	–	–	–	240	2·56
450–500	16	77	24	31	12	3	1	3	–	1	–	–	–	–	–	–	–	–	–	–	168	1·80
500–550	18	32	12	16	4	5	–	2	1	–	–	–	–	–	–	–	–	–	–	–	90	0·96
550–600	11	18	4	11	3	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–	50	0·53
600–650	17	2	4	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	29	0·31
650–700	7	1	1	3	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13	0·14
700–750	5	2	2	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	11	0·12
750–800	5	1	1	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8	0·09
800–850	6	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6	0·06
850–900	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0·02
900–950	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0·02
Total	224	769	511	253	684	731	777	359	231	763	681	571	729	593	736	744	–	–	–	–	9,356	–

*Not recorded.

1935-6

Table 19.—(*contd*).

Frequency class in ounces	A	B	C	D	E	F *	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	Totals	Percentage
0–50	166	667	404	137	447	–	162	54	52	412	149	87	156	281	367	32	98	26	45	170	3,912	37·43
50–100	28	71	71	54	133	–	157	80	45	122	188	29	376	179	225	44	92	16	28	293	2,231	21·35
100–150	16	17	21	36	49	–	135	109	40	99	164	71	174	60	96	60	42	16	11	146	1,362	13·03
150–200	9	8	10	14	35	–	127	122	25	71	103	131	18	16	40	93	53	6	9	18	908	8·69
200–250	12	4	6	7	10	–	80	115	32	32	65	192	1	6	17	102	13	3	4	2	703	6·73
250–300	8	2	1	4	8	–	59	116	29	11	28	129	–	–	2	109	15	7	6	–	534	5·11
300–350	3	–	1	1	5	–	35	94	10	–	12	70	–	–	1	105	5	6	1	–	349	3·29
350–400	1	–	–	2	1	–	14	64	3	2	1	27	–	–	–	88	1	2	2	–	208	1·99
400–450	–	–	–	–	1	–	3	36	–	1	–	8	–	–	–	63	–	2	–	–	114	1·09
450–500	–	–	–	–	2	–	2	27	1	–	1	3	–	–	–	32	–	5	1	–	74	0·71
500–550	–	–	–	–	–	–	3	11	–	–	–	3	–	–	–	12	–	4	–	–	33	0·32
550–600	–	–	–	–	–	–	–	5	–	–	–	–	–	–	–	5	–	1	–	–	11	0·11
600–650	–	–	–	–	–	–	–	2	–	–	–	–	–	–	–	4	–	2	–	–	8	0·08
650–700	–	–	–	–	–	–	–	1	–	–	–	–	–	–	–	1	–	–	–	–	2	0·02
700–750	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	0·01
750–800	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
800–850	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
850–900	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
900–950	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
950–1000	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1000–1050	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1050–1100	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
1100–1150	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	0·01
Total	243	769	514	255	691	–	777	836	237	750	711	750	725	542	748	750	319	98	107	629	10,451	

*Crop failed.

1936-37

Table 19.—(*contd*).

Frequency class in ounces	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S *	T	Totals	Per-centage
0–50	63	105	83	69	150	277	289	203	165	486	476	152	549	482	681	133	207	24	–	658	5,252	50·00
50–100	27	168	95	51	81	224	138	51	41	147	112	150	118	123	80	175	55	12	–	26	1,874	17·84
100–150	13	214	119	39	40	133	121	28	25	75	52	178	64	25	3	148	29	10	–	–	1,316	12·53
150–200	22	203	94	35	35	76	87	19	8	20	37	137	32	1	–	112	12	13	–	–	943	8·97
200–250	16	76	48	23	22	17	71	17	2	10	21	88	13	–	–	71	11	11	–	–	517	4·92
250–300	21	23	40	24	10	3	38	21	–	2	10	46	2	–	–	51	2	7	–	–	300	2·86
300–350	20	4	18	9	1	2	19	7	1	3	4	14	1	–	–	43	1	2	–	–	149	1·42
350–400	18	1	8	4	–	–	9	9	–	–	4	9	–	–	–	23	2	3	–	–	90	0·85
400–450	14	–	1	1	–	–	5	3	–	–	–	2	–	–	–	5	–	7	–	–	38	0·36
450–500	5	–	–	–	–	–	–	–	–	–	–	1	–	–	–	–	–	1	–	–	7	0·07
500–550	1	–	–	–	–	–	–	1	–	–	–	1	–	–	–	–	–	3	–	–	6	0·06
550–600	5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	7	0·07
600–650	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	2	0·02
650–700	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
700–750	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	0·01
750–800	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	–	–	2	0·02
Total	226	794	506	255	339	732	777	359	242	743	716	778	779	631	764	761	319	99	–	684	10,504	–

*Crop failed.

Table 19 gives the frequency classes for yield of cherry. To facilitate grasping the significance of the figures a frequency polygon for the total yields for the three years is given and also one for a typical estate. (Not printed.)

It is not necessary to labour the fact that a large percentage of the trees, in any one year, are not contributing their fair share of yield. Over the whole twenty estates for three successive years two-thirds of the crop has been given by less than one-third of the trees. Further search has been made for material and sites of a more uniform character but these are few. Irregularity due to age (as experienced by inability to establish supplies satisfactorily in gaps) is apparently an important factor.

The practical lesson is that much more care in first planting is necessary. Failures in this respect in the past have been, it would appear, mainly due to speculative establishment of plantations with a view to early sale. In the worst cases it is worthy of consideration whether or not to replant a limited area each year, in other words, grow coffee in a rotation varying in length according to the suitability of the locality and the financial position of the planter. Such then is the material on which it is desired to carry out experiments.

One of the first investigations was to learn the percentage increase that it would be necessary to obtain from the block under study in the event of carrying out experiments. A further important point was the most suitable size of plots. Table 20 gives a summary obtained from the analysis of variance for the four estates on which it was decided to attempt experiments. It is seen from a perusal of this data that no block in any one year was suitable. Increases due to treatments of the order of sixty per cent of the mean would have had to be obtained. Fortunately when combining the yields of two years a large reduction in plot error and percentage increase of means is often obtained. There is furthermore a definite prospect of still more increasing the precision of the experiments by the use of the method of co-variance (i.e. the regression of the mean of two years experimental yields on the mean of two years natural yields). As the result of the recording of natural yields it is therefore now possible to proceed with experiments on the variable material available with a strong possibility of showing up reasonable increases in yield due to the treatments under trial. These preliminary records of natural yields are however necessary for all blocks on which experiments are to be carried out unless much less variable planting material can be located. This work is essential and its need is confirmed by authorities in England. It is next necessary to consider plot size. If trees of varying yield are not well mixed the larger the number of trees per plot the more even will tend to be the mean plot yield. If the number is increased unduly, however, the environment factors such as soil and topographical features will vary to such an extent as to outweigh any advantage in increasing tree numbers.

TABLE 20.

Estates on which Experiments have been laid down in 1936.

Estate	Year	Mean per plot	Plot error	Significant difference required
		ounces	per cent	per cent
B	1934/5	722	29·07	46·49
	1935/6	3,975	13·62	21·78
	1936/7	2,802	20·23	32·36
	Mean of 1934/5–1935/6	2,348	11·19	17·90

TABLE 20.—(*contd.*)

Estate	Year	Mean per plot	Plot error	Significant difference required
		ounces	per cent	per cent
F	1934/5	2,243	28·32	45·30
	1935/6	2,857	30·06	48·08
	1936/7	2,028	32·69	52·28
	Mean of 1934/5–1935/6	2,550	20·83	33·32
L	1934/5	2,342	39·72	63·53
	1935/6	1,938	37·31	59·67
	1936/7	887	40·08	64·11
	Mean of 1934/5–1935/6	2,140	28·96	46·32
O	1934/5	64	89·96	143·89
	1935/6	1,262	31·06	49·68
	1936/7	359	24·63	39·40
	Mean of 1934/5–1935/6	663	31·82	50·89

1934/5 and 1935/6 are natural yields. 1936/7 is first experimental yield.

Furthermore, the smaller the blocks necessary for an experiment the more of the latter can be carried out. Accordingly a detailed study was made on two estates in regard to the effect on the error of the experiment for increasing number of trees per plot. The larger plots were not built up from contiguous trees but the same latin square was superimposed afresh on the yield plan, at random, for each plot size in turn. Plots of the same size were located on the same trees for each year. Table 21 sets out the results obtained.

TABLE 21A.—*Estate E.*

Trees per plot	Year	Mean per plot	Plot error	Significant difference required
		ounces	per cent	per cent
6	1934/5	97	48·19	77·08
	1935/6	1,418	33·30	53·26
	1936/7	1,081	21·34	34·13
	Mean of 1934/5 and 1935/6	757	33·90	54·22
9	1934/5	174	35·23	56·35
	1935/6	2,128	20·84	33·33
	1936/7	1,185	23·24	37·17
	Mean of 1934/5 and 1935/6	1,151	21·45	34·31
12	1934/5	172	42·92	68·66
	1935/6	3,034	36·22	57·94
	1936/7	1,975	30·35	48·55
	Mean of 1934/5 and 1935/6	1,603	36·36	58·16
16	1934/5	320	37·48	59·94
	1935/6	3,835	29·23	46·76
	1936/7	2,348	21·89	35·02
	Mean of 1934/5 and 1935/6	2,077	29·76	47·60

TABLE 21A.—*Estate E.* (*contd.*)

Trees per plot	Year	Mean per plot	Plot error	Significant difference required
		ounces	per cent	per cent
	1934/5	383	24·34	38·93
	1935/6	4,943	19·34	30·93
20	1936/7	2,985	27·45	43·91
	Mean of 1934/5 and 1935/6	2,663	19·44	31·09
	1934/5	457	22·32	35·70
	1935/6	6,075	17·86	28·57
25	1936/7	3,632	24·05	38·48
	Mean of 1934/5 and 1935/6	3,266	17·82	28·50
	1934/5	575	28·92	46·26
	1935/6	7,510	22·62	36·18
30	1936/7	4,009	27·30	43·67
	Mean of 1934/5 and 1935/6	4,042	23·01	36·80
	1934/5	646	26·24	41·98
	1935/6	9,181	20·95	33·51
36	1936/7	5,186	23·30	37·27
	Mean of 1934/5 and 1935/6	4,913	21·19	33·90

TABLE 21B.—*Estate F.*

Trees per plot	Year	Mean per plot	Plot error	Significant difference required
		ounces	per cent	per cent
	1934/5	779	44·49	71·16
	1935/6	907	38·43	61·47
6	1936/7	532	39·14	62·60
	Mean of 1934/5 and 1935/6	842	23·52	37·63
	1934/5	1,038	52·96	84·71
	1935/6	1,476	27·65	44·22
9	1936/7	956	43·78	70·02
	Mean of 1934/5 and 1935/6	1,257	22·71	36·32
	1934/5	1,377	39·87	63·76
	1935/6	1,570	24·01	38·40
12	1936/7	1,064	35·98	57·55
	Mean of 1934/5 and 1935/6	1,473	22·42	35·85
	1934/5	2,083	28·09	44·94
	1935/6	2,300	25·63	41·00
16	1936/7	1,348	32·96	52·71
	Mean of 1934/5 and 1935/6	2,191	10·78	17·24
	1934/5	2,300	35·06	56·08
	1935/6	2,879	29·04	46·45
20	1936/7	1,838	39·10	62·54
	Mean of 1934/5 and 1935/6	2,589	20·75	33·19

TABLE 21B.—*Estate F.* (*contd.*)

Trees per plot	Year	Mean per plot	Plot error	Significant difference required
		ounces	per cent	per cent
25	1934/5	2,904	28·37	45·38
	1935/6	3,489	30·35	48·55
	1936/7	2,665	32·77	52·41
	Mean of 1934/5 and 1935/6	3,196	23·10	36·94
30	1934/5	3,525	29·97	47·94
	1935/6	4,151	32·26	51·59
	1936/7	2,961	30·89	49·40
	Mean of 1934/5 and 1935/6	3,838	20·56	32·89
36	1934/5	4,294	25·57	37·70
	1935/6	4,543	36·38	58·19
	1936/7	3,745	27·18	43·47
	Mean of 1934/5 and 1935/6	4,418	18·41	31·04

Estate E is a block of young Blue Mountain coffee with an almost negligible yield in 1934. In 1935 too heavy a crop was carried and allowed to mature. In consequence combining the results of natural yields for two years has done little to lower the standard error which closely follows that of 1935. The error is less than twenty per cent so that nothing is gained in accuracy by increasing plot size beyond twenty trees.

Estate F is one of Kent's coffee about ten years old. It bore steadily during the period. The mean of two years natural yield has definitely enabled the error to be lowered. The trough at "sixteen trees per plot" is easily explained by examination of the yield figures. By chance the trees were an exceptionally even lot. Again a standard error of about twenty per cent has been obtained and the twenty-tree plot seems a quite suitable size.

There is much irregularity in both estates in plots of less than twenty trees and nothing appears to be gained by increase beyond this number. The twenty-tree plot has therefore been adopted for all ordinary experiments on estates.

(b) *Experiments on Estates and Native Holdings.*—Following upon the completion of the above preliminary but essential work in early 1936, it was decided to attempt simple experiments on four recorded estates. Three others had to be postponed owing to factors beyond our control. A summary of these experiments follows.

Each is laid down as a four-by-four latin square. Each plot consists of twenty trees and is surrounded by a double guard row of non-treated trees. The general object was to find out the affect of nitrogen on yield and growth of coffee in areas where soil appears to have adequate phosphorus and potash but possibly a small nitrogen shortage using the most readily obtainable fertilizers.

EXPERIMENT I.—*Estate B.*

Particulars:—Variety of coffee ... ... Bourbon.
Planted in field ... ... 1927. Age in 1936—9 years.
Planting distance ... 9ft. by 9ft.
Shade ... ... None.
Soil ... ... Heavy alluvial loam.
Annual rainfall about 34in.

Preliminary Data.

Year	Plot mean ounces cherry	Tree mean ounces cherry	Plot error percentage	Significant difference needed percentage
1934-35 ...	723 ...	36 ...	29·1 ...	46·5
1935-36 ...	3,975 ...	199 ...	13·6 ...	21·8
Mean of above ...	2,349 ...	117 ...	11·2 ...	17·9
1936-37 ...	2,802 ...	140 ...	20·2 ...	32·4

The treatments applied are—

(a) Grass mulch ... ... 112lb. 4 plots.
(b) Pen manure ... ... 56 ,, 4 ,,
(c) Sulphate of ammonia ... $\frac{1}{2}$,, 4 ,,
(d) Control—no treatment ... —

Unfortunately the planter applied treatments without consulting us and no analysis of applications was done.

EXPERIMENT II.—*Estate F.*

Particulars:—Variety of coffee ... ... Kent's imported from India.
Planted in field ... ... 1927. Age in 1936—9 years.
Planting distance ... 10ft. by 10ft.
Shade ... ... Irregular Grevillia robusta.
Soil ... ... Red chocolate clay loam, volcanic.
Annual rainfall about 37in.

Preliminary Data.

Year	Plot mean ounces	Tree mean ounces	Plot error percentage	Significant difference percentage
1934-35 ...	2,243 ...	112 ...	28·3 ...	45·3
1935/36 ...	2,857 ...	143 ...	30·1 ...	48·1
Mean ...	2,550 ...	128 ...	20·8 ...	33·3
1936-37 ...	2,028 ...	101 ...	32·7 ...	52·3

The treatments are—

(a) Control—no treatment.
(b) Sulphate of ammonia (20·6 per cent N) 1lb. per tree.
(c) Grass mulch 100 ,, ,,
(d) Pen manure 40 ,, ,,

and were applied in January 1936.

Analysis of Materials.

	Cattle manure	Grass (unnamed) per cent
1. Dry matter	67·0 ...	91·0
2. Carbon	14·1 ...	45·3
3. Nitrogen	1·14 ...	·403
4. C/N Ratio	12·4 ...	112
5. Ash	4·1 ...	9·28
6. $P_2 O_5$	1·54 ...	·32
7. $K_2 O$	1·81 ...	0·45
8. Soil	33·5 ...	—

Experiment III.—*Estate L.*

Particulars:—Variety of coffee ... ... Bourbon.
Planted in field ... ... 1912. Age in 1936—24 years
Planting distance ... 8ft. 6in. by 6ft. 6in.
Shade ... ... Grevillea robusta 30ft. by 20ft.
Soil ... ... Red chocolate clay loam, volcanic.
Rainfall ... ... Average for about 8 years 60in.

Preliminary Data.

Year	Plot mean ounces	Tree mean ounces	Plot error percentage	Significant difference percentage
1934 ...	2,342 ...	117 ...	39·7 ...	63·5
1935 ...	1,938 ...	97 ...	37·3 ...	59·7
Mean ...	2,140 ...	107 ...	29·0 ...	46·3
1936-37 ...	887 ...	44 ...	40·1 ...	64·1

The treatments for which were applied in January 1936, are—

(a) Control—no treatment 4 plots.
(b) Pen manure 60lb. ,,
(c) Banana leaf mulch 100 ,, ,,
(d) *Sulphate of ammonia 1 ,, ,,

Analysis of Materials.

	Banana leaf	Cow manure
1. Dry matter	93% ...	48%
2. Nitrogen	·92 ...	·82
3. Carbon	·45 ...	18·8
4. C/N	·49 ...	·23
5. Ash	8·9 ...	4·9
6. K_2O	2·0 ...	1·22
7. P_2O_5	·33 ...	1·03

Experiment IV.—*Estate O.*

Particulars:—Kind of coffee ... ... Bourbon.
Planted in field ... 1926. Age in 1936—10 years.
Planting distance ... 10ft. by 10ft. and one in middle.
Shade ... ... Grevillea robusta 30ft. by 20ft.
Soil ... ... Poor red loam.
Rainfall ... ... Average over four years 40in.

Preliminary Details.

Year	Plot Mean ounces	Tree Mean ounces	Plot error percentage	Significant difference percentage
1934 ...	64 ...	3 ...	90·0 ...	143·9
1935 ...	1,262 ...	63 ...	31·1 ...	49·7
Mean ...	663 ...	33 ...	31·8 ...	50·9
1936-37 ...	359 ...	18 ...	24·6 ...	39·40

Treatments which were applied in November 1936, are—

(a) Guinea grass 100lb. 4 plots.
(b) Pen manure 40 ,, ,,
(c) †Sulphate of ammonia 1 ,, ,,
(d) Control.

Analyses of guinea grass and pen manure were not done. Yields for the experimental plots have been recorded for the first year, 1936-37, and at the end of next season the mean yield of treatments for the two years will be analysed.

*Second application in July 1936. †Second application of ½lb. in July 1936.

It is improbable that interactions for locality for all experiments will be done as means and plot errors are not sufficiently alike and the comparison is therefore not permissible.

TABLE 22.—EXPERIMENTS FOR 1937.

Estate	Year	Mean (ounce per plot)	Plot error (percentage)	Significant difference (percentage)
C	1934/5	2,690	28·73	45·94
Twenty trees per plot	1935/6	1,200	47·41	75·83
4×4 latin square	1936/7	887·5	28·86	46·15
	Mean 1935/6 and 1936/7	1,044	27·98	44·75
	Mean 1934/5, 1935/6 and 1936/7	1,592·5	18·105	28·96
	1934/5	923	21·45	34·32
D	1935/6	1,478	13·12	20·99
Twenty trees per plot	1936/7	913	33·07	52·89
	Mean 1935/6 and 1936/7	1,195·5	17·47	27·95
4×4 latin square	Mean 1934/5, 1935/6 and 1936/7	1,105	13·91	22·25
E	1934/5	376	30·86	49·35
Twenty trees per plot	1935/6	5,002	23·11	36·96
	1936/7	2,557	29·60	47·35
4×4 latin square	Mean 1935/6 and 1936/7	3,779·5	15·82	25·30
	Mean 1934/5, 1935/6 and 1936/7	2,645	15·98	25·56
K	1934/5	2,328	30·35	48·55
Twenty trees per plot	1935/6	crop failed	—	—
	1936/7	1,316	15·20	24·31
4×4 latin square	Mean 1934/5 and 1936/7	1,822	21·80	34·87
	Mean 1934/5, 1935/6 and 1936/7	—	—	—
M	1934/5	6,277	13·43	18·10
Twenty trees per plot	1935/6	422	35·66	48·05
Randomized blocks	1936/7	2,539	25·52	34·39
4 treatments × 5 blocks	Mean 1935/6 and 1936/7	1,480·5	24·18	32·59
	Mean 1934/5, 1935/6 and 1936/7	3,079	13·66	18·40
P	1934/5	3,596	26·05	41·66
Twenty-four trees per plot	1935/6	5,379	19·75	31·59
	1936/7	1,855	47·54	76·05
4×4 latin square	Mean 1935/6 and 1936/7	3,617	18·99	30·37
	Mean 1934/5, 1935/6 and 1936/7	3,610	20·36	32·56

Projected Experiments.—In 1937 the following new experiments are being laid down on recorded blocks:—

1. To study the effects of the application of various organic substances on the water holding capacity of non-retentive soils where irrigation is necessary. On two estates.
2. To learn the effects on yields and tree growth of four systems of pruning. On one estate.
3. To investigate the effects of four strengths of spraying materials in the control of *Hemileia vastatrix* on *Coffea arabica*. On two estates.
4. To find out the effects of composts of different strengths on the yield of *Coffea arabica* on a volcanic ash and their effect on soil texture. On two estates.
5. To learn the best method of supplying the vacancies in old established coffee. On two estates.
6. To attempt a comparison of methods of "top-working" old coffee. On two estates.
7. To study the effects of various forms of phosphate on a site known to be deficient in phosphorus. On one estate.

Table 22 gives the constants for the above estates.

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SECTION Vc.—On the Station.

Experiment VIII.—Soil Erosion Demonstration.

(c) *On the Station.*—The demonstration consists of a series of eight adjacent plots each 100 feet (down the slope) by 14ft. 9in., or approximately one-thirtieth of an acre, on a uniform slope of 1 : 6. The land was in heavy bush up to March 1934. The soil is classified as a tropical red earth, partially laterized, the field texture is that of a clay loam with a fairly high moisture retaining capacity. The subsoil is a deep, freely drained, chocolate-red clay, friable throughout the profile. The plots are separated along their length and closed at the top by concrete blocks sunk into the soil and protruding three to four inches above the general soil surface. At the bottom of each plot there is a concrete tank in which the eroded soil and run-off water are collected.

The treatments, which were commenced on the 21st March 1934 and may be considered to have been effective by the 1st February 1935 are as follows:—

Plot 1. Control.
,, 2. Contour hedge on bund (bunds 32 feet apart).
,, 3. Control.
,, 4. Contour hedge on bund and procumbent cover crop.
,, 5. Control.
,, 6. Cover crop (procumbent).
,, 7. Mixed cover crop.
,, 8. Control.

All plots were planted with coffee at a spacing of nine by nine feet on the 30th April 1934. Up to December 1935 the controls were kept clean weeded, the weeds being left on the surface. Plot 2 was weeded when the weeds reached flowering stage. The plots having contour hedges (2 and 4) had three hedges of *Crotalaria* spp. in each case; the hedges were on bunds thirty-two feet apart,

the lowest being two feet above the concrete tank. The procumbent cover crop used was *Dolichos hosei*; the mixed erect cover crop consisted of *Crotalaria* spp. and *Canavalia ensiformis*.

From January 1936 onwards modifications were introduced in certain instances; in two of the control plots, Nos. 3 and 8, the weeds were placed in rows across the slope.

Prior to the big rains in both 1935 and 1936 the following treatments were given:—

(a) Each tree in each plot was envelope forked.
(b) Control plots (1, 3, 5 and 8) were "jembe" forked from top to bottom.
(c) Contour hedge plot (2) was treated as those in (b).
(d) Contour hedge and procumbent cover crop (4) and procumbent cover crop (6) and mixed erect cover crop (7) plots were envelope forked over the whole of their area.

Table 23 gives the actual weight of dry soil lost in the years 1935 and 1936 in tons per acre. These amounts are also expressed as percentage of the top foot of soil.

TABLE 23.

Plot No.	Plot each 1/30 acre	Loss per acre in tons (dry soil)		Expressed as a percentage of top foot of soil	
		1935	1936	1935	1936
8	Control	18·55	16·2	1·27	1·11
3	„	8·34	21·6	0·57	1·48
1	„	10·90	32·4	0·75	2·22
5	„	14·10	28·8	0·967	1·97
2	Crotalaria hedge 32 feet apart	0·86	5·4	0·059	0·37
4	Crotalaria hedge and cover crop	0·08	0·4	0·0055	0·03
6	Cover crop, procumbent	0·174	0·3	0·0114	0·02
7	Cover crop, erect, Crotalaria and Cannavallia	0·174	6·0	0·0114	0·41

The loss of soil per acre in 1935 varies from 8·3 tons to 18·5 tons. It is possible that variation in soil conditions may be responsible for a portion of this difference, but from an examination of the individual plots it appears that the merging of individual furrows has occurred more on plots 8 and 5 than on the other two controls; this would appear to be mainly responsible for the differences.

In 1935, plot 2, Crotalaria hedge, has a high figure compared with those of the other anti-erosion treatments. It is partially explained by two breaks through, due to gaps in the hedge, and also by the fact that the hedges became silted up to the extent of two to three inches and then an overflow occurred.

The figures for soil loss from the individual plots in 1936 show an increase in every case; this is due in part to increased rainfall and secondly to treat ment modifications. Thus in the *Crotalaria* hedge plot (2), the hedges became silted up completely and with each downpour of rain there was an overflow and in the case of the erect cover crop plot (7) the various species of *Crotalaria* failed to reseed the plot effectively, a 60 per cent cover only being obtained.

Table 24 gives the rainfall for the periods of the big rains of 1935 and 1936.

TABLE 24.—*Rainfall for 1935-36.*

Millimetres.

Date	February		March		April		May		June		July	
	1935	1936	1935	1936	1935	1936	1935	1936	1935	1936	1935	1936
1	—	—	4·7	—	—	11·1	30·0	18·8	7·9	—	7·8	—
2	—	—	—	—	30·4	—	69·7	34·7	19·0	18·4	4·4	0·3
3	—	—	8·9	—	20·4	—	39·4	6·8	2·0	—	—	0·6
4	0·1	—	7·6	0·4	0·25	14·3	7·8	112·7	—	—	—	29·9
5	17·2	—	—	—	0·3	0·2	21·6	104·3	1·0	—	2·3	13·5
6	1·2	—	0·5	—	13·6	25·2	120·0	0·7	0·6	—	0·6	0·4
7	0·5	—	—	8·8	0·5	9·3	33·7	8·0	2·0	7·8	1·7	2·6
8	3·4	—	21·7	4·4	2·3	12·6	74·0	36·5	—	18·7	1·2	3·5
9	—	—	4·5	13·6	9·3	2·7	21·5	27·4	—	3·5	—	3·3
10	3·25	—	6·6	—	0·6	46·7	53·0	6·5	—	1·4	7·2	1·0
11	—	—	6·8	—	—	38·1	35·7	11·9	0·1	—	2·0	8·1
12	0·75	—	5·5	—	5·5	17·8	9·0	35·6	8·3	9·2	0·2	—
13	2·8	—	12·9	0·6	104·0	2·1	2·6	23·5	6·1	46·8	—	—
14	—	—	—	17·4	10·8	9·7	—	31·3	8·1	36·5	—	—
15	—	3·8	2·4	3·3	3·7	19·2	—	3·5	—	—	—	—
16	—	39·3	—	—	—	41·4	0·8	7·8	—	2·6	0·5	—
17	—	0·1	—	3·0	1·0	68·4	1·1	17·6	0·8	1·8	—	0·6
18	—	27·9	0·5	—	0·6	120·8	1·4	2·8	13·5	5·1	—	3·4
19	—	13·3	—	—	16·3	40·0	25·5	48·0	6·6	1·8	—	2·8
20	45·75	—	18·1	—	1·25	22·8	25·7	49·5	—	1·6	—	3·0
21	87·0	—	3·6	0·8	—	44·2	2·0	2·5	0·4	3·9	0·1	9·8
22	1·5	13·1	—	—	—	16·4	24·1	4·0	—	1·0	—	22·5
23	—	7·5	—	0·5	—	0·8	18·3	—	—	3·0	2·5	—
24	31·0	18·6	0·5	—	1·5	—	22·8	—	—	4·8	4·5	0·8
25	32·0	1·2	2·2	4·0	0·3	22·7	7·8	3·0	—	9·0	—	0·6
26	—	2·1	5·5	1·1	16·2	31·5	70·8	0·9	4·5	0·2	—	—
27	6·9	8·1	—	—	47·3	20·5	10·0	25·0	11·3	12·9	—	—
28	—	0·1	—	—	34·5	31·7	0·4	23·0	41·0	25·0	—	—
29	—	—	—	—	2·8	29·9	—	22·8	0·2	7·0	—	—
30	—	—	0·5	—	29·0	52·4	1·6	5·4	—	—	4·8	—
31	—	—	—	—	—	—	0·5	0·9	—	—	4·0	—
	233·85	135·1	113·0	57·9	352·4	752·5	730·8	675·4	133·4	222·0	43·8	106·7

The approximate average loss in tons per acre from the controls and treatments are—

	1935		1936
Controls	13·0	...	25·0
Treatments	0·32	...	3·0

and expressed as a percentage of the top foot of soil—

Controls	2·57	per cent
Treatments	0·045	,,

The 1936 average figure for treatments is very much higher proportionately than the corresponding figure for 1935; this is due to the ineffectiveness of the treatments in plots 2 and 7. The erosion on these two plots is responsible for 94 per cent of the total of the treatment plots. The two treatments maintained effectively (viz. the procumbent cover crop (6) and procumbent cover crop with hedge (4)) lost an average of 0·35 tons per acre as compared with the average for all treatments of 25 tons in 1936.

Table 25 gives the run-off in gallons per acre for the seasons 1935 and 1936 respectively at various dates. It will be seen that the rate of run-off per acre in 1936 from the controls was 114,000 compared with 37,000 gallons from the treatments, a ratio of approximately 3 to 1, whereas the soil loss is in the ratio of approximately 12 to 1.

TABLE 25.

Run-off in Gallons per Acre.

Date	Plots								Rain total mm.	Intensity
	8	3	1	5	2	4	6	7		
12-13.4.35	2,940	2,460	1,560	2,610	1,560	1,440	1,740	2,040	104	76mm. in one hour
3-7.5.35	4,620	5,520	6,240	4,560	3,420	—	1,320	2,520	142·6	
9-10.4.36	1,440	1,320	960	3,240	960	720	840	1,080	50	20mm. in one hour
17-18.4.36	*15,840	11,160	*15,840	*16,320	11,400	4,200	4,560	8,100	125	50mm. in one hour
18-19.5.36	3,480	4,560	5,760	*14,280	1,440	660	540	1,320	43	20mm. in one hour
12-13.6.36	2,940	300	3,780	2,400	420	420	480	240	47	12mm. in one hour

*Tank overflowed.

The mechanical analysis of the material eroded during 1935 indicated that in each plot the soil had been eroded *in toto*.

Table 26 gives the percentage soil moisture at 15 inches in the plots named on the 16th November 1936, after a two-months drought.

TABLE 26.

Sample	2 Crotalaria hedge	4 Hedge and cover crop	1 Control	6 Cover crop	7 Erect cover crop	Means
I	25·0	22·5	26·0	23·5	22·5	23·9
II	24·5	22·0	28·0	23·5	22·0	24·0
III	25·5	25·0	28·5	24·5	24·5	25·6
IV	24·0	25·5	27·0	22·5	22·0	24·2
V	24·5	22·5	24·0	23·0	22·5	23·3
						General mean
	24·7	23·5	26·7	23·4	22·7	24·2

Significant difference (P=0·5)=1·48.

Thus the control is significantly higher than all the treatments. It should be noted, however, that the erect cover crop was planted in August just prior to the dry period.

The soil moisture content at a depth of fifteen inches on terraces immediately adjacent to the erosion demonstration was significantly higher than that of all the treatments but not that of the control. It is of interest to note that there were no differences between the plots so far as soil moisture was concerned on the 18th July 1935.

On the 21st December 1936, after three months' drought, the coffee in the controls has maintained much more leafage than that in the treatments. The leaf counts on the trees show that the average number of leaves per tree in the various plots are as follows:—

(All trees are of the same age and from the same parcel of seed).

		Average number of leaves
Crotalaria hedge and cover crop	(4)	194
Procumbent cover crop	(6)	163
Control	(1)	454

A further observation was made to the effect that the trees in the controls flowered more quickly in response to rain, a difference of five days being observed.

It is quite definite from the results of two seasons' observations that anti-erosion measures are very necessary. The fact remains, however, that under such conditions as existed between September and December 1936, the condition of the coffee in the controls (no treatment) was better than that in the plots in which anti-erosion measures were applied. This was due, probably almost entirely, to differences in soil moisture content. It now remains to consider possible anti-erosion measures which do not deplete soil moisture in times of drought but aid its retention.

It has been shown that the soil moisture content of terraces is maintained at approximately the same level as that of the controls despite a hedge growing on the bund; there are, however, objections to terracing, namely, cost and the considerable disturbance of the soil. Contour hedging has been shown to be effective as an anti-erosion measure provided the hedges are frequent enough but, in view of the figures obtained for soil moisture under the conditions of the demonstration, it is inadvisable to consider the hedge plant as permanent in coffee areas where droughts of two to three months' duration are likely to occur; the only methods in such cases are either to throw up contour bunds only, or to throw up contour bunds and plant with a hedge, the latter to be planted with the rains and uprooted at the end of the rains. In areas where soil moisture is not likely to be a limiting factor the hedge plant can be considered permanent.

The superficial distance between the contour bunds should not be more than twenty feet. On steeply sloping land this distance will have to be considerably less. It is so often forgotten that the main idea of an anti-erosion measure is to prevent the accumulation of water and hence reduce its transporting power. (Box ridging or terracing is a modification of contour hedging to prevent water accumulation through lateral flow in the area between two contours.)

The treatments on the demonstration will be modified for the season 1937. Control No. 5 will be mulched with banana leaves, the contour hedge plot (No. 2) will have the superficial distances between the hedges reduced to sixteen feet, and the hedge plant sown with the rains and removed in June or July, but controls Nos. 1, 3 and 8 will be treated as in the 1936 season.

Hybridization Work.

Hybridization work, using trees in different localities, introduces considerable difficulties, the chief of which is making the trees flower simultaneously or within one week of each other in which case pollen may be stored.

The best available recorded trees of each of the Bourbon, Kents and Blue Mountain types were used. The original project was to obtain intercrosses between annual bearers in each of the three types and also between annual and biennial bearers in each of the Bourbon and Blue Mountain types. This had to be modified owing to the differing times of flowering of the various trees. Where necessary pollen was stored over calcium chloride. Using this method pollen remained viable for a period of eight days. Crosses between Kents and Bourbon, Bourbon and Blue Mountain and Kents and Blue Mountain have been effected.

Plate 1

Plate 2

[*To face page 62*

Plate 3

Plate 4

Compost Making.

Experiments as to methods suitable for the making of compost under the conditions existing at the station have been carried out.

In the first instance the Indore method was followed with success, the period in which complete breakdown took place varied with the season of the year but as an average three to three and a half months was required. Pits were used originally and were quite successful during the drier period of the year but in the rains the pits became water-logged with consequent detrimental effects in the compost making. Heaps have been used since.

The Indore method was stopped and instead of daily charging of the compost heap, the latter was removed every seven days only. The material did not break down satisfactorily, probably due to too much manure per unit of material. The method was then further modified by introducing well withered material into the litter and thoroughly mixing and also removing the litter twice per week.

The procedure adopted at present is as follows:—

1. A mixture containing approximately 70 per cent well withered material and 30 per cent fresh material is used for bedding.

2. The material is cleaned out daily and placed in layers of approximately six inches thick over an area of twenty feet by nine feet. This is continued for six days.

3. As each layer is spread it is sprinkled with a slurry of the following composition:—

1 mature compost
½ wood ash
½ material fourteen days old
1 urine earth

4. The heap is turned after fourteen days and inoculated with material from a heap thirty days old.

5. The material is turned again after a further fourteen days (i.e. one month old).

6. The heap is turned again after a further thirty days (i.e. two months old).

7. Heaps are watered as required. The amount of moisture in the heap is an important factor, too little or too much is equally detrimental of the requisite action.

Observations.

Observations on (1) the behaviour of soils from various estates where uniformity trials are being carried out, and (2) clonal material planted in those soils; the only variant is therefore the soil.

A cubic metre of soil was brought from each of eight sites, and packed layer by layer into their respective concrete tanks. The coffee, all raised vegetatively from one parent tree and chosen for equal size, was planted on the 23rd September 1935, two months after rooting. The following measurements of drainage during the period 15th April 1936 to the 30th July 1936 (long rains) are of interest.

TABLE 27.

Soil Drainage (Gallons).

Month	Estate							C.R.S.
	C	D	E	F	L	N	O	
18th to 30th April	49·5	26·2	45·8	33·3	34·2	32·9	29·1	40·6
May	80·4	36·2	75·6	64·0	66·3	36·3	38·6	37·1
June	33·1	18·9	16·5	17·4	17·1	8·6	10·2	3·4
July	11·4	15·3	18·8	15·3	10·3	5·3	8·7	5·7
Total ...	174·4	95·6	156·8	130·0	127·9	83·1	86·6	86·8

Mean, 117·8 gallons.

The rates of growth of the coffee varied, the plant growing in soil from Estate E attained a height of 1·22 metres and was topped back to 60cm. on the 3rd February 1937. This plant flowered and set fruit during January 1937 at eighteen months from time of rooting. Plants in soil from Estates D and C.R.S. flowered in March 1937. The following table gives the diameter of the various plants at three inches above soil level, together with the height on the 30th March 1937.

TABLE 28.

Soil from estate	Height	Diameter at 7·5cms. above soil level	
C	113·8cms.	... 2·7cms.	
D	101·3 ,,	... 2·9 ,,	
E	64·0 ,,	... 3·0 ,,	Topped back to 64cms. on 3-2-37 from 112·5.
F	101·9 ,,	... 2·8 ,,	
L	107·6 ,,	... 2·6 ,,	
N	114·9 ,,	... 2·6 ,,	
O	92·5 ,,	... 2·3 ,,	
C.R.S. ...	75·6 ,,	... 2·9 ,,	Topped back on 15-3-37.

The trees in soil from Estate N suffered severely from the effects of leaf miner in October 1936.

EXPERIMENT I.

Details: (a) Project.—To test the effect on subsequent growth of seven different methods of planting. The different methods are—

1. No holing at all. Seedlings to be put in with least disturbance of ground.
2. Hole prepared the size of a "debe"—opened up at least three months before use and filled in with surface soil one month before planting.
3. Hole opened the size of a "debe" and filled in again at once—one month before planting.
4. As per method 2 but bottom of hole sub-soiled one foot deep before filling in.
5. As per method 3 but hole sub-soiled before filling in.

6. As per method 4 but compost mixed with soil at time of filling—half a debe to one hole.
7. As per method 5 but with compost as at 6.

In each plot of four by five trees, one in each of four to be—

(a) deep planted—ball planting;
(b) deep planted—bare roots;
(c) nursery level—ball planting;
(d) nursery level—bare roots.

Observations made during the first season showed that the percentage age deaths in the various groups were as follows:—

Method	Percentage deaths
Deep planted—roots bare	56
,, ,, —ball planted	17·5
Nursery level—ball planted	7·5
,, ,, —bare roots	5·0

At two years old the deep planted trees do not appear as vigorous as those planted at nursery level.

Pot Culture Experiments.

The object of these experiments was to observe the symptoms in coffee of the so-called deficiency diseases, that is, diseases due to a lack of essential nutrients. The technique followed was that used successfully by Dr Wallace of the Long Ashton Research Station to whom I am grateful for help and advice.

Sixteen unglazed pots (eight inch) containing eighteen pounds of sterilized sand were used. The coffee seedlings were six leaved when planted and were selected for uniformity of size both as regards roots and foliage. The pots were enclosed in wooden cases to limit evaporation, etc. Each group consisted of four trees, one group received the complete nutrient (see note 1) another received a nutrient entirely lacking in nitrogen, a third group a nutrient entirely lacking in potash and the fourth a nutrient entirely lacking in phosphate. Within each group two seedlings received a special nutrient (see note 2) consisting of copper, manganese and boron. The nutrients were applied three times per week and the special nutrient once per fortnight, distilled water was given on the remaining days. Each pot was leached every fourteen days.

The treatments were commenced on the 11th May 1935. The first symptoms of abnormal growth were shown by leaves of the potash deficient series on the 27th May 1935; these consisted of a yellowing at the periphery of the older leaves, the yellowing commenced at the top of the leaf and spread along the edge and inwards towards the main vein. By the 4th July 1935, the yellow edges had become brown and a fortnight later half the leaf had become brown and papery. This sequence continued in this series for the duration of the experiment.

On the 27th June 1935 the nitrogen deficient series were chlorotic—chlorosis continued finally causing leaf fall; new leaves were put out slowly.

There were no definite symptoms in the phosphate deficient series even after a year.

Two trees, one from the complete nutrient series and one from the nitrogen deficient series, each receiving the special nutrient were weighed, etc., on the 8th June 1936, and the following data obtained:—

	Complete nutrient	Nitrogen deficient
Number of leaves	82	12
Weight	76·93 grammes	8·9 grammes
Weight of roots (dry)	17·0 ,,	2·5 ,,
Weight of stem	38·41 ,,	2·55 ,,
Height	18·0 inches	11·37 inches

Analysis showed that the carbohydrate content of the nitrogen deficient root was very small when compared with that of the complete nutrient.

The experiment is being continued in a modified form in order to obtain information as to the symptoms of deficiencies in coffee trees at the fruiting stage. One tree from each of the potash deficient series and phosphate deficient series has been brought to the flowering stage, only a small amount of flower has been produced however.

Fifteen month old seedlings are being grown in sand culture and are receiving a complete nutrient until such time as they flower and set fruit. When this has occurred they will be divided into groups and each group will receive a nutrient solution differing in composition in one essential element from that being applied to the other groups. The following plates, although not showing the leaf symptoms are of interest:—

Plate 1 shows the four plants receiving the complete nutrient. Numbers 3 and 4 received the special nutrient in addition.

Plate 2 shows four plants receiving a nutrient entirely deficient in potash salts. Numbers 5 and 7 received the special nutrient in addition.

Plate 3 shows four plants receiving a nutrient entirely deficient in nitrogen. Numbers 16 and 15 received the special nutrient in addition.

Plate 4 shows four plants receiving a nutrient entirely deficient in phosphate. Numbers 11 and 12 received the special nutrient in addition.

In plates 1 and 2 those trees not receiving the special nutrient are smaller and show a more compact growth, the same applies to trees number 10 in plate 4 but the habit is less marked and does not occur in tree number 9 which was treated similarly.

In plate 3 the trees receiving the special nutrient (15 and 16) show less leafage than those receiving only a nutrient deficient in nitrogen.

Note 1.—Complete Nutrient Solution.

	Grammes
Potassium nitrate	6·0
Calcium nitrate $Ca(Ho_3)_2\ 4H_2O$	1·4
Di-potassium mono-hydrogen phosphate	1·0
Calcium sulphate	2·0
Magnesium sulphate	3·0
Sodium chloride	0·5
Ferric chloride	0·4
Rain water to one litre.	

One litre concentrate diluted with nine litres of rain water before application.

Note 2.—Special Nutrient.

	Grammes
Copper sulphate Cu SO_4 $5H_2O$	0·01
Manganese sulphate Mn SO_4 $7H_2O$ ...	0·01
Boron hydroxide B $(OH)_3$	0·0112
Rain water to one litre.	

One litre of above concentrate diluted with nine litres rain water previous to application.

The applications were—

100c.c. of the nutrient solution on alternate days.
125c.c. of distilled water in the remaining days.
100c.c. of the special nutrient every fourteen days.
Each pot was leached every fourteen days.

Experiment IV.

Observation plots, in an aggregate eight acres, of the following have been planted. The material will probably be used as seedling stocks on which will be grafted scions of high yielding local strains.

Arabica	*Robusta*
No.	
143 }	R 1 }
144 }	R 2 } Amani selections
145 }	R 3 }
146 }	R 4 }
147 } Introductions from Central	Bukobensis
148 } America and Belgian	Canephora
149 } Congo	UR 226 } In nursery for planting
150 }	UR 227 } later
151 }	Sudan Robusta
152 }	Uganda Robusta
Kents local	Excelsa
Bourbon	Stenophylla
Rasha Rasha RRI	Eugenoides
Blue Mountain	Swynnertonii
Haarar	Congensis hybrid
Marogogipe	Mufindiensis

Experiment XII.

Details: (a) Project.—To investigate the value of seedling selection in the nursery.

(b) Material.—Bourbon. Six months old seedlings. Seed from Kibosho planted in nursery on the 1st October 1934.

The material is graded as follows—

(1) big roots, tops cut back; (2) big roots, large tops; (3) average; (4) small roots, large tops; (5) big roots, small tops; (6) small roots, small tops.

(c) Layout.—Randomized blocks. Twelve trees per plot. Each plot repeated four times. Guard row round whole experiment.

The following facts and observations were recorded during the course of the experiment:—

1. It was necessary to supply in the first season the following numbers of trees to the various grades:—

(1) Five trees (2) Nil
(3) One tree (4) Nil
(5) Six trees (6) Two trees

At the end of the second season the following were the total number of plants in each group:—

(1) Forty-four (2) Forty-eight
(3) Forty-eight (4) Forty-eight
(5) Forty-four (6) Forty

Table 29 given below gives the mean height attained by the various grades at six monthly intervals. Height is no longer a measure of the superiority of group (2)—this is shown by the volume figure given in Table 30.

TABLE 29.

Particulars	First measurement	Second measurement	Increment
Large tops, big roots ...	23·50	46·50	23·00
Average	19·75	40·75	21·00
Large tops, small roots ...	21·25	41·50	20·25
Small tops, big roots	14·00	30·00	16·00
Top cut back	12·25	25·25	13·00
Small tops, small roots ...	10·00	23·00	13·00
General mean	16·79	34·50	17·71
Standard error	0·47	1·44	1·07
Significant difference ...	1·62	4·98	3·11

TABLE 30.

Cubic capacity expressed as a percentage of the mean (100 per cent) 15th July 1936.

2. Large tops, big roots	154·49
3. Average	118·21
4. Large tops, small roots	125·35
5. Small tops, big roots	68·78
1. Tops cut back, good roots ...	47·15
6. Small tops, small roots	86·05

Significant difference 79·66 per cent.

From these observations given in the above tables the best nursery selections have maintained their position throughout. It is of interest to note that group 4, large tops, small roots, take second place both as regards increment and volume.

EXPERIMENT XIV.

Mulch Experiment.

(a) Project.—To compare the effect of various forms of surface ground treatment on the growth and yield of *Coffea arabica*.

(b) Treatments

1. Banana mulch—dry—alternate lines.
2. Grass mulch—dry—alternate lines.
3. *Crotalaria evantulensis*—planted in long rains—as mulch in dry season.

4. *Crotalaria evantulensis*—planted in short rains—as mulch in wet season.
5. Clean weeded—as necessary—weeds on contour ridge.
6. Weeds—as mulch in dry season.
7. Cover crop in long and in short rains used as mulch when rains cease.
8. Clean weeded plus compost (=mulch).

Note.—Half plots to have balanced fertilizer twice a year.

(c) Layout.—Randomized blocks repeated six times. Plots of twelve trees. No shade—aspect south-east. Guard row round each plot.

Difficulty was experienced in establishing *Crotalaria evantulensis* in the long rains and the growth of *C. juncea* during the small rains of 1936 was poor and when cut down afforded little mulch.

The effect of soil treatment on the incidence of *Dasus simplex*, the dusty ground beetle, observed by the entomologist, are of interest.

The average number of beetles per tree in the individual plots are as given below:—

Banana mulch	0·08
Weeds as mulch	1·00
Cover crop in long rains and as mulch when rains cease	1·09
Compost mulch	5·75
Grass mulch	5·85
Clean weeded	6·09
Crotalaria in long rains	8·42
,, in short rains	19·25

Note.—None of these figures are statistically significant.

Soil moisture determinations carried out during periods of drought appear in the chemist's report. It would be seen that these illustrate clearly how effective banana leaf mulch is in maintaining a high level of soil moisture during drought.

Lyamungu
31st March 1937

F. R. Sanders
Agricultural Officer

SECTION VI.—Report of the Chemist.

The chemist went on vacation leave on the 5th July 1936 and returned to duty on the 20th February 1937.

Station Investigations.

1. *Nitrification studies and the effect of cultural treatments.*—(A) During the period October 1935 to July 1936, periodical observations were made of the production of nitrate (a) on clean-weeded plots which had been hoed after the long rains and (b) on plots growing a procumbent cover crop—*Dolichos Hoseii*.

The amounts of nitrate-nitrogen present in the top-soil from time to time are shown below:—

TABLE 31.

Nitrate-nitrogen in top-soil expressed as parts per million of oven dry-soil.

Date	Clean-weeded plots	Under cover crop
1st October 1935 ...	35·0	11·0
1st November 1935 ...	41·5	16·0
15th December 1935 ...	53·0	27·5
7th January 1936 ...	15·0	5·5
15th February 1936 ...	26·0	7·5
16th February 1936 ...	3·5	4·0
6th March 1936 ...	8·0	5·0
20th March 1936 ...	16·5	9·5
7th April 1936	7·5	6·0
22nd April 1936	2·0	2·0
18th May 1936	1·7	1·6
1st June 1936	1·2	1·2
8th June 1936	2·3	2·8
22nd June 1936	2·6	4·6
29th June 1936	2·1	4·3

During the period of heavy rainfall in April and May 1936 the amounts of nitrate present were at a minimum owing to low temperatures and excessive soil moisture. We may assume that similar conditions held during the heavy rains of April, May and June 1935. Then as moisture conditions and soil temperatures became more favourable, nitrification proceeded apace until the end of December: during this period rain was very occasional and insufficient to cause leaching into the sub-soil.

At the end of December three inches of heavy rain occurred causing a leaching of nitrate into the immediate subsoil, the concentration of nitrate in the top-soil thus falling considerably. There succeeded fine weather with occasional showers which were insufficient to cause leaching, and concentrations of nitrate again rose until mid-February when heavy rains, spread over four days, caused further leaching. Conditions again became favourable and a further accumulation of nitrate took place until the heavy and almost continuous rains in April and May. At the end of May the amount of nitrate present at various depths of a profile sampled in a neighbouring site showed that leaching had been very deep, there being less than 0·5 parts per million in any horizon down to a depth of eight feet.

Throughout the period under review the amount of nitrate present under the cover crop was lower than that in the clean-weeded soil. This may be partially due to the absorption of nitrate by the cover crop and partially to the effect of the "jembe" cultivation in stimulating nitrate production. Evidence in support of this latter effect is afforded by observations made on Experiment IX, where a comparison was made of the nitrate production when the soil had been (a) cultivated with "jembe," (b) envelope-forked and (c) left uncultivated. Thus—

Treatment	Nitrate-Nitrogen in parts per million	
	6.11.35	9.12.35
(a) Cultivated with hoe ...	56	44
(b) Envelope-forked	36	32
(c) Uncultivated	34	30

(B) *Observations on the influence of Mulching on soil moisture conditions and on nitrate production.*

Experiment XIV was laid down in August 1935 to learn the effect of various types of ground treatment on the growth of coffee. Soil samples from these experimental plots have been examined periodically to observe the effect of the treatments on soil moisture and production of nitrate. Until all the treatments are properly established, however, accurate data on all the treatments will not be forthcoming. Even so some valuable data has been obtained during the last year.

The estimations of nitrate in the top-soils are tabulated in Table 32.

TABLE 32.

Nitrate-nitrogen. Parts per million.

Treatment	30/3/36	15/4/36	14/5/36	23/2/37	5/3/37	11/3/37	23/3/37
1	20·9	3·9	4.2	43·1	50·2	58·0	60·6
2	18·9	2·6	6·0			58·2	70·4
3	16·8	4·6				53·0	
4	9·8	5·1				51·3	
5	21·0	4·5	2·0	33·2	42·5	51·6	64·4
6	4·9	4·1				57·8	
7	11·9	4·0				58·0	
8	18·5	3·1				59·3	67·6

30-3-36. Treatments 5 and 1 greater than 3, 4, 6 and 7.
,, 8 and 2 ,, ,, 4, 6 and 7.

15-4-36. / 15-5-36. Differences were not significant.

23-2-37. / 5-3-37. Differences between 1 and 5 were significant.

11-3-37. / 23-3-37. Differences were not significant.

No significant differences between the eight treatments were found during the long rains of 1936. Unfortunately the writer was absent during the two months which succeeded the rainy season, when important differences in nitrate content might become apparent. However, determinations of soil moisture content at different depths in times of prolonged drought throw light on the observed beneficial effect of banana leaf mulch. The conservation of soil moisture is illustrated by the following figures:—

SOIL MOISTURE DETERMINATIONS.

16-12-36. In time of prolonged drought, the soil moisture at different depths and under varying treatment was as follows:—
(The figures represent the percentage of moisture held by oven-dried soil.)

	Depth 0-6 ins	6-12 ins	12-18 ins
Control. Plots clean-weeded ...	18·8	22·6	26·9
Under grass mulch	19·1	25·4	29·6
,, banana leaf mulch	41·5	38·7	39·1

23-2-37. In time of a second prolonged drought.

Control	15·5	22·0	26·0
Under banana leaf mulch	27·5	35·0	37·5

		Depth 0-6 ins	6-12 ins	12-18 ins
9-3-37.	After $2\frac{1}{2}$ inches of rain, most of which was effective.			
	Control	32·5 ...	54·0 ...	33·0
	Under grass mulch	35·0 ...	39·0 ...	35·0
	,, banana leaf mulch	41·0 ...	41·0 ...	39·0
23-3-37.	Few very light showers intervening.			
	Control	30·0 ...	33·0 ...	32·5
	Under grass mulch	34·0 ...	36·0 ...	34·0
	,, banana leaf mulch	41·0 ...	39·0 ...	38·0

We see here that during the December drought, when the clean-weeded plots were dried out to 19 per cent moisture, the soil under the banana mulch was still very moist—in fact at the moisture content corresponding to its moisture equivalent. The drying out of the subsoil was also prevented. In the February drought, the clean-weeded soil was approaching the wilting coefficient, which is about twelve per cent in this soil. That under the banana leaf mulch had then only lost half of its available moisture.

This maintenance of soil moisture and moderate temperature under the mulch means also that nitrification can proceed right throughout the dry season. From Table 32, we see that in February, the soil under the mulch contained 33 per cent more nitrate in the surface soil than the bare soil—the equivalent of an extra 78 pounds sulphate of ammonia.

The moderate rains falling in late February and early March stimulated nitrification generally. At first the soil under the mulch remained richer in nitrate, but eventually all the treatments drew level. As heavy rains succeeded this sudden rise in nitrate content, it is likely that much would be leached deep into the subsoil: in which case the plants which had been able to feed during the dry weather owing to the maintenance of moisture under the mulch would be much better off for nitrogen than those under other treatments.

2. *Soil Survey.*—The collection of soil samples from uniformity trial plots has been continued. The laboratory examination of fourteen profiles has been completed and tables of analyses are presented below. The data tabulated are to be regarded primarily as standards of comparison for each particular area. The amounts of nutrients in the various profiles vary considerably. One would suggest a possible lack of phosphate and potash in Estates P and T. The amount of humus in Estates O, C, A and Q are also below the average.

Brief Field Notes.

1. *Selian, Arusha.*—Altitude 4,400 feet. Rainfall 32 inches. Volcanic ash soil. A very fine textured grey friable loam. Compacts firmly when wet and becomes very powdery when dry.

2. *Nduruma, Arusha.*—Altitude 4,400 feet. Rainfall 45 inches. Grey powdery ash with some degree of crumb structure, increasing in the subsoil, which is a moderately friable clay. Murram-like concretions appear in the third foot overlying decomposing lava at 36 inches.

3. *Ngare Nairobi.*—Altitude 4,300 feet. Rainfall 16 to 28 inches. Kilimanjaro lava soil. A deep, friable, chocolate-red porous clay loam the top foot of which becomes hard-baked during drought.

4. *Sanya.*—Altitude 4,000 feet. Rainfall 40 inches. Volcanic ash soil. A fine textured powdery dark grey ash, rather stony, overlying a table of shattered lava at a depth of twelve to twenty-four inches; the ash penetrates the crevices between the lava rubble to a considerable depth.

5. *Boloti.*—Altitude 4,100 feet. Rainfall 36 inches. Kilimanjaro lava soil. Friable chocolate clay loam of great depth and apparently uniform throughout.

6. *Lyamungu* (*Mlasani*).—Altitude 4,500 feet. Rainfall 60 inches. Kilimanjaro lava soil. An extremely friable soft sandy loam chocolate-red in colour, overlying a sandy clay loam with nut-like structure.

7. *Lyamungu, Usagara.*—Altitude 4,400 feet. Rainfall 65 inches. Kilimanjaro lava soil. Dark chocolate-brown clay loam of considerable depth moderately friable.

8. *Uru.*—Altitude 4,100 feet. Rainfall 60 inches. Kilimanjaro lava soil. A dark chocolate friable clay loam, very uniform throughout.

9. *Kilema Mission.*—Altitude 4,300 feet. Rainfall 75 inches. Kilimanjaro lava soil. A very friable loam light brown or chocolate in colour. The colour becomes more yellow with increasing depth until the sixth foot which is grey and more clay like, resembling decomposed lava.

10. *Marangu.*—Altitude 3.900 feet. Rainfall 40 inches. Kilimanjaro lava soil. Brownish-chocolate friable sandy loam of great depth.

11. *Mamba.*—Altitude 4,000 feet. Rainfall 45 inches. Kilimanjaro lava soil. A deep chocolate loam of great depth, apparently uniform throughout the profile.

12. *Kibosho Mission.*—Altitude 4,850 feet. Rainfall 78 inches. Kilimanjaro lava soil. A shallow, stony, chocolate-brown sandy loam, overlying lava rock at a depth of four to five feet.

13. *Lushoto.*—Altitude 4,000 feet. Rainfall 45 inches. Soil derived from gneiss. A grey-brown sandy loam overlying a very deep bright-brown sandy clay loam.

Lyamungu, Coffee Research Station.—Altitude 4,400 feet. Rainfall 75 inches. Kilimanjaro lava soil. Dark chocolate-brown clay loam of considerable depth, moderately friable throughout.

ANALYSIS OF FINE EARTH

Selian 1.

	Reaction pH. Water	Reaction KCl	% C	% N	C/N	Exch. Bases m.g.e. % Total	Exch. Bases m.g.e. % K_2O	P_2O_5 r.a. ppm.	Air Dry H_2O %	Sticky Point H_2O %	Sand %	Index of Texture
Comp.	7·0	6·8	3·04	·232	13·1	36·2	6·85	619	7·8	42·0	41·5	35
1	6·8	5·7	2·18	·162	13·4	30·8	4·60	578	8·2	40·5	43·5	33
2	7·0	5·8	1·61	·133	12·1	30·8	4·34	566	9·3	43·5	40·0	36·5
3	7·0	5·8	1·26	—	—	33·5	5·96	578	10·0	44·0	40·0	37·5
4	7·0	5·8	1·32	—	—	32·2	6·02	566	9·4	42·5	39·5	36

Nduruma 2.

Comp.	6·7	5·5	4·50	·238	18·9	36·6	3·77	810	8·1	43·5	23·0	40
1	5·2	4·8	4·55	·376	12·1	22·8	4·45	722	7·3	44	23·5	40
2	6·0	5·9	4·05	·218	18·6	34·0	3·08	635	10·2	44·5	22·5	41
3	6·7	5·4	2·98	—	—	29·9	1·72	542	10·3	43	19·5	40
4	6·9	5·4	2·41	—	—	28·6	1·57	468	10·3	40·5	21·5	37
5	6·9	5·5	2·24	—	—	27·2	1·74	510	11·5	41·5	20·0	38

Ngare Nairobi 3.

Comp.	6·8	5·6	2·05	·183	11·3	22·1	2·46	385	—	—	—	—
1	7·0	5·4	2·25	·199	11·3	22·1	2·54	242	7·1	39·5	14·5	37
2	6·4	5·4	1·76	·157	11·2	22·3	1·93	239	7·4	40·5	12·5	38·5
3	6·2	5·4	1·57	—	—	22·3	1·11	271	7·5	40·0	11·0	38
4	6·4	5·6	1·37	—	—	22·3	1·00	275	7·2	40·5	11·0	38·5
5	6·8	5·7	1·16	—	—	22·8	1·04	361	7·3	38·5	11·5	36·5
6	6·9	6·0	·78	—	—	25·0	1·15	443	7·4	38·5	11·5	36·5
7	6·9	6·2	·70	—	—	25·7	1·18	605	7·7	38·5	11·0	36·5
8	7·0	6·4	·66	—	—	26·8	1·27	703	7·3	36·5	11·0	35

ANALYSIS OF FINE EARTH.—(*contd.*).

Sanya 4.

	Reaction pH. Water	Reaction KCl	% C	% N	C/N	Exch. Bases m.g.e. % Total	Exch. Bases m.g.e. % K_2O	P_2O_5 r.a. ppm.	Air Dry H_2O %	Sticky Point H_2O %	Sand %	Index of Texture	Stones & Gravel % (variable)
Comp.	7·3	6·5	5·16	·350	14·7	42·8	3·47	798	7·6	47	32	41·5	20-40
1	7·1	6·4	5·13	·348	14·7	41·3	2·97	802	8·0	47	32	41·5	34-84
2	6·2	5·2	3·08	·197	15·6	27·7	2·87	574	9·0	44·5	35	38·5	49-72
3	6·0	4·7	2·24	—	—	24·1	4·00	561	9·6	45·5	38·5	39	50
4	5·3	4·6	1·71	—	—	23·0	3·71	608	10·0	47·0	50	38·5	57-70
5	5·3	4·6	1·00	—	—	20·3	5·18	612	9·0	47·5	58	36·0	69-72
6	5·5	5·0	1·00	—	—	26·8	7·88	612	9·2	43·5	60	33·5	18-22

Boloti 5.

Comp.	7·7	6·1	4·01	·301	13·3	30·3	2·76	745	6·5	45·5	—	—	—
1	6·9	5·9	2·37	·208	11·4	19·9	1·40	127	5·7	42·5	6·5	41·5	—
2	6·2	5·2	1·92	·180	10·7	15·4	1·12	104	6·6	43·5	6·5	42·5	—
3	6·1	5·1	1·72	—	—	14·3	0·40	104	6·6	41·5	—	—	—
4	6·0	5·0	1·46	—	—	13·6	0·40	113	6·5	42·0	7·0	41·0	—
5	6·3	5·1	1·20	—	—	12·7	0·40	118	6·3	39·0	—	—	—
6	6·2	5·1	·81	—	—	12·3	0·40	108	6·0	38·0	7·0	37·0	—
7	6·2	5·1	·59	—	—	10·3	0·39	106	6·0	40·0	—	—	—
8	6·1	5·2	·45	—	—	10·0	0·42	87	5·8	40·5	5·5	39·5	—

Lyamungu 6.

Comp.	6·2	5·4	3·32	·358	9·2	19·4	1·92	385	—	54·5	—	—	—
1	6·2	5·2	2·96	·312	9·5	18·3	1·15	357	13·6	53·5	17·0	50·5	—
2	6·1	4·9	2·30	—	—	15·2	1·00	256	14·4	53·0	19·0	50·0	—
3	6·1	4·9	2·16	—	—	14·2	·80	256	14·1	56·0	20·5	52·5	—
4	6·2	5·0	1·92	—	—	14·7	·69	206	15·1	55·0	20·5	51·5	—
5	6·0	5·0	1·92	—	—	14·1	·82	150	17·0	56·0	21·0	52·5	—
6	6·1	5·0	1·45	—	—	13·1	·56	115	19·2	60·5	12·5	58·5	—
7	6·2	5·0	·72	—	—	10·7	·32	110	19·8	60·5	8·0	59·0	—
8	6·1	5·1	1·02	—	—	9·3	·41	106	18·5	56·5	10·5	55·0	—

ANALYSIS OF FINE EARTH.—(*contd.*).

LYAMUNGU, USAGARA 7.

	Reaction pH. Water	Reaction KCl	% C	% N	C/N	Exch. Bases m.g.e. % Total	Exch. Bases m.g.e. % K_2O	P_2O_5 r.a. ppm.	Air Dry H_2O %	Sticky Point H_2O %	Sand %	Index of Texture
Comp.	6·9	5·7	3·74	·352	10·6	27·4	2·87	619	14·2	49	12·5	47·0
1	7·1	5·6	3·51	·350	10·0	27·2	2·48	650	14·5	51	12·5	49·0
2	6·8	5·9	2·24	·250	8·9	25·4	2·31	520	12·6	49	12·5	47·0
3	6·7	5·6	1·58	—	—	18·5	2·19	542	12·7	47	11·5	45·0
4	6·5	5·5	1·13	—	—	17·4	2·23	482	15·3	49·5	9·5	48·0
5	6·6	5·3	·89	—	—	16·1	2·31	347	11·9	48	9·5	46·5
6	6·5	5·2	·80	—	—	13·4	1·90	124	12·1	47	10·0	45·5
7	6·5	5·3	·66	—	—	11·6	1·59	140	12·6	—	10·0	—
8	6·3	5·3	·49	—	—	9·8	1·56	156	13·2	—	9·5	—
9	6·0	5·5	·35	—	—	9·2	2·12	—	19·1	57·5	14·0	55·0

URU 8.

Comp.	7·2	5·2	3·87	·360	10·7	14·9	1·51	87	13·8	50·0	—	—
1	6·0	5·2	3·15	·310	10·1	15·8	1·21	52	15·5	47·0	10·5	45·5
2	6·2	5·2	1·81	·191	9·4	14·9	0·69	50	13·6	48·5	10·0	47·0
3	6·2	5·1	1·17	—	—	11·6	0·89	60	14·9	48·5	9·5	47·0
4	6·2	5·1	·84	—	—	10·3	1·15	62	15·3	52·0	9·5	50·5
5	5·9	5·0	·68	—	—	9·5	1·09	81	16·9	52·0	12·0	50·0
6	5·8	4·9	·62	—	—	8·3	0·83	94	20·5	55	8·0	54·0
7	5·7	4·9	·65	—	—	9·2	1·20	98	18·2	55·5	8·0	54·5
8	5·9	4·9	·57	—	—	9·2	1·29	157	16·4	53	8·5	51·5

ANALYSIS OF FINE EARTH.—(*contd.*).

KILEMA 9.

	Reaction pH. Water	Reaction KCl	% C	% N	C/N	Exch. Bases m.g.e. % Total	Exch. Bases m.g.e. % K_2O	P_2O_5 r.m. ppm.	Air Dry H_2O %	Sticky Point H_2O %	Sand %	Index of Texture
Comp.	7·5	6·9	3·54	·344	10·3	27·7	2·81	432	9·5	44·5	25	40·5
1	5·9	4·8	3·31	·311	10·7	13·7	2·54	187	9·6	41	25	37·0
2	6·1	4·9	2·40	·244	9·8	11·3	1·93	65	10·9	42·5	23·5	39·0
3	6·0	5·0	1·61	—	—	4·6	1·11	42	13·2	44·5	20	41·5
4	6·0	5·2	1·04	—	—	4·6	1·11	29	12·4	43	23	39·0
5	5·7	5·3	·56	—	—	0·8	·30	33	10·7	41	35	35·5
6	5·0	4·7	·21	—	—	1·1	·54	39	12·9	47·5	30	42·5
7	4·6	4·0	·35	—	—	2·1	·41	29	16·9	60·0	8	58·5
8	4·6	3·9	·41	—	—	2·2	·41	35	12·8	54·5	11·5	53·0

MARANGU 10.

Comp.	7·2	5·9	2·83	·201	14·1	21·5	1·46	280	6·5	36·5	22	33	—
1	7·0	5·7	2·81	·196	14·3	20·9	1·48	270	6·6	34·5	22	31	—
2	7·0	5·9	2·26	·158	14·3	21·1	1·13	286	6·3	35·0	—	—	—
3	7·0	5·8	1·67	—	—	16·1	·70	171	6·5	34·5	27	30	—
4	7·0	5·8	1·35	—	—	16·2	·70	160	6·4	34	—	—	—
5	6·8	5·7	·73	—	—	14·1	·27	59	6·3	35	26	32·5	—
6	6·6	5·7	·44	—	—	10·8	·18	56	6·3	38	—	—	—
7	6·5	5·8	·43	—	—	7·8	·19	42	6·3	40	19·5	37	—
8	6·6	5·9	—	—	—	6·4	·17	40	6·7	40	—	—	—

ANALYSIS OF FINE EARTH.—(*contd.*).

	Reaction pH. Water	Reaction KCl	% C	% N	C/N	Exch. Bases m.g.e. % Total	Exch. Bases m.g.e. % K_2O	P_2O_5 r.a. ppm.	Air Dry H_2O %	Sticky Point H_2O %	Sand %	Index of Texture	Stones and Gravel
Mamba 11.													
Comp.	6·4	5·7	2·86	·274	10·4	22·0	2·07	788	8·1	40·5	—	—	—
1	6·2	5·5	2·82	·262	10·7	20·9	1·01	432	9·0	41	27·0	36·5	—
2	6·7	5·6	2·48	·238	10·4	21·8	0·46	419	8·7	41	25·0	37	—
3	6·5	5·5	1·67	—	—	15·7	0·50	271	8·9	39	—	—	—
4	6·2	5·5	1·24	—	—	12·6	0·49	168	8·8	39·5	21·5	36	—
5	6·1	5·5	1·02	—	—	10·8	0·41	91	10·2	42	—	—	—
6	5·8	5·4	·80	—	—	9·0	0·31	106	11·1	43	19·0	40	—
7	5·6	5·2	·62	—	—	5·9	0·28	79	10·6	43	—	—	—
8	5·8	5·4	·48	—	—	4·6	0·31	67	10·0	43	21·5	40	—
Kibosho Mission 12.													
Comp.	6·5	5·0	3·21	·312	10·3	17·9	2·31	96	11·4	55·0	—	—	—
1	6·4	5·0	3·32	·334	10·0	18·5	2·09	92	12·1	54·5	36·5	48·5	7·0
2	6·4	4·9	2·37	·260	9·1	16·9	1·35	62	13·2	53·5	41	46·5	14·5
3	6·5	5·1	2·27	—	—	15·2	·80	42	13·8	53	39	46·5	13·5
4	6·8	5·2	2·26	—	—	14·5	·80	42	13·3	56·0	35	50	29·0
5	6·3	5·2	2·08	—	—	12·0	1·35	42	14·8	59	32	53·5	32·0
6	6·1	5·1	1·24	—	—	7·8	2·05	19	17·5	63	35	57	54·5
7	5·5	5·2	·49	—	—	1·1	·65	23	11·8	44	74·5	32	67·5

	Reaction pH. Water	Reaction KCl	% C	% N	C/N	Exch. Bases m.g.e. % Total	Exch. Bases m.g.e. % K_2O	P_2O_5 r.a. ppm.	Air Dry H_2O %	Sticky Point H_2O %	Sand %	Index of Texture
Comp.	7·2	5·9	4·32	·367	11·8	21·9	0·48	28	8·6	—	—	—
1	6·8	5·6	2·96	·271	10·9	14·9	0·51	10	8·4	46·0	28·0	39
2	6·6	5·6	1·65	·170	9·7	11·3	0·32	20	8·9	42·5	26·0	38·5
3	6·5	5·5	·80	—	—	6·5	0·27	28	7·7	40·0	25·0	36
4	6·5	5·6	·68	—	—	6·0	0·19	22	8·0	40·0	26·0	36·0
5	6·3	5·6	·56	—	—	5·5	0·17	26	7·8	41·5	25·5	37·5
6	6·4	5·8	·52	—	—	5·1	0·23	37	7·4	43·5	24·5	39·5
7	5·7	6·9	·40	—	—	4·6	0·19	40	6·7	45·0	23·5	41·0
8	5·3	5·2	·42	—	—	4·6	0·27	38	6·6	43·0	25·5	39·0
COFFEE RESEARCH STATION.												
Comp.	7·5	6·6	4·25	·530	9·25	36·1	2·91	420	10·6	51·5	—	—
1	7·6	7·4	4·05	·438	9·25	29·0	2·40	229	10·8	52	10·5	50·5
2	7·3	6·9	2·51	·266	9·4	24·1	1·67	198	10·7	46	13·0	44·0
12″—24″	7·1	6·0	1·48	—	—	17·2	2·18	146	9·6	46·5	12·0	44·5
2′—3′	7·0	5·7	1·01	—	—	13·6	3·41	113	10·8	49	9·5	47·5
3′—4′	6·7	5·6	·78	—	—	11·6	3·34	68	10·4	51·5	9·5	50·0
4′—5′	6·0	5·4	·46	—	—	7·4	1·58	85	9·5	55·5	10·5	54·0
5′—6′	5·7	5·3	·34	—	—	7·2	·98	100	10·6	56·0	9·0	54·5

NOTES.

Soil reaction ... ... = Is measured in the pH units both in water and in normal KCl solution.
C% ... ... = Percentage organic carbon. For conversion to organic matter, multiply by 1·724.
N ... ... = Total nitrogen.
Exch. Bases ... ... = Exchangeable bases, measured in milligram equivalents per 100 grams of soil (m.g.e.%).
P_2O_5 r.a. ... ... = Readily available P_2O_5, viz., that soluble in $\frac{N}{500}$ sulphuric acid, buffered to pH 3·0.
ppm. ... ... = Parts per million.
Air Dry H_2O ... ... = Moisture driven off when the air-dried soil is heated at 100-105 C.
Sticky Point H_2O ... ... = Moisture content of soil when kneaded to the maximum degree of stickiness expressed on oven-dry weight.
Index of Texture ... ... = Is measured by subtracting from sticky point moisture, the amount of moisture supposed to be held by [the sand fraction.
Comp. ... ... = Composite sample of top soil.
Nos. 1 to 8 ... ... = Represent depths of soil in the profile: 0-6ins, 6ins-12ins, 12ins-18ins, 18ins-24ins, 24ins-36ins, 36ins-48ins, 48ins-60ins, 60ins-72ins, respectively, unless otherwise stated.

A.—Profile.

ANALYSIS OF FINE EARTH.

	Reaction pH		%	%	C/	Exch. Bases m.g.e.%		P_2O_5	Air Dry	Moisture	Sticky	Sand	Index	Stones
	Water	KCl	C	N	/N	Total	K_2O	r.a. ppm.	H_2O %	equivalent %	Point H_2O %	%	of Texture	and Gravel %
Comp.	6·97	5·92	2·18	·187	11·3	20·6	4·36	184	4·1	—	34	69	23	—
1	7·3	5·9	2·26	·203	11·1	21·0	4·71	286	4·4	20·0	32	69	21	6·2
2	7·4	6·1	—	·178	—	21·4	4·52	200	4·2	20·0	34	69	23	2·7
1′—2′	7·2	6·0	—	—	—	21·0	4·36	160	5·7	—	36	68	25	2·2
2′—3′	7·3	6·0	—	—	—	22·3	5·14	160	6·4	25·0	35	72	24	6·5
3′—4′	7·5	6·0	—	—	—	18·6	5·76	160	5·5	—	31	80	18	5·0
4′—5′	7·7	5·9	—	—	—	18·1	5·89	100	5·2	18·7	30	77	18	2·9
5′—6′	7·9	6·0	—	—	—	13·2	3·52	76	2·9	10·5	31	86	17	5·0

B.—Profile.

Comp.	7·2	5·9	2·12	·175	12·1	33·9	4·98	333	9·2	—	45	—	40	—
1	7·1	5·8	2·44	·190	12·8	32·4	4·35	345	8·9	34·4	46	39	40	0·4
2	7·1	5·8	—	·168	—	31·2	3·83	208	10·4	35·4	49	40	42	0·3
1′—2′	7·2	5·9	—	—	—	29·9	3·44	244	10·4	—	46	36	40	0·4
2′—3′	7·3	6·0	—	—	—	29·9	3·61	238	11·7	32·7	46	34	40	0·3
3′—4′	7·3	5·9	—	—	—	31·2	3·42	286	10·9	—	47	32	42	0·4
4′—5′	7·3	5·9	—	—	—	32·1	3·05	216	12·7	37·0	46	32	41	Nil
5′—6′	7·7	6·2	—	—	—	18·7	6·71	92	14·0	42·4	50	35	45	0·5

3. *Investigations on Field Problems.*—A. Overbearing, "yellowing" and die-back in West Arusha.

Investigations have been made to study soil conditions which may be contributory causes of the typical die-back experienced in West Arusha. Advantage was taken of the fact that there existed almost side by side, and therefore subject to the same climatic conditions, two soil types: a lighter soil (A) on which considerable loss of coffee trees occurs, and a heavier type, (B) on which trouble of this kind is not experienced to any marked extent. Soil profiles were inspected and sampled on each soil type. Laboratory examination of the two series indicate a marked lack of balance in the supplies of nitrogen and potassium. The analytical data are presented on the apposite page.

It will be seen that both soils are low in organic matter and therefore, potentially, in available nitrogen. The textures are very different; the lighter soil contains about seventy per cent of sand throughout the profile, where the heavier type contains about forty per cent. The lighter soil has a much lower moisture equivalent throughout the profile and leaching of nitrates will commence so much earlier than on the heavier type. The lighter soil will dry out more rapidly also, so that we may expect nitrification to be arrested so much sooner; moreover, whatever nitrate is produced will be more subject to leaching beyond the range of roots in times of heavy rainfall.

The samples were collected after a considerable amount of rain had fallen: the lighter soil was then freely drained, whereas a water table was found seven to eight feet below the surface of the heavier soil. All these factors confirm the idea of a low nitrogen status, particularly in the lighter soil.

Coming then to other plant nutrients, we find very high percentage of exchangeable potassium in both types, but more particularly in the lighter soil, which is at the same time poorer in other bases. The lighter soil is also poorer in available phosphate. No salts were found in either profile.

One feels justified in diagnosing a lack of balance in nutrition as between nitrogen and potassium, with a doubtful interaction from phosphate. Field trials with organic nitrogenous manures are shortly to be undertaken.

(B) *Non-fruiting of Coffee at Mufindi.*—Soil samples were collected from estates in Mufindi area to find whether the inability of the coffee to produce fruit could be ascribed to any particular mineral deficiency.

The soils were found to contain only very small amounts of bases and phosphate although very rich in organic matter—up to 10 per cent organic carbon, and 0·8 per cent total nitrogen. Here we have a lack of balance in nutrients working in the opposite direction from that occurring in West Arusha. Excessive nitrogen causes the plant to specialize in vegetative growth.

(C) A number of soil samples sent from Njombe District were submitted for examination to find whether they were suitable for growing coffee. They proved to be similar to soils on which coffee had failed to be an economic proposition.

4. *General.*—A number of well waters in the Sanya area were examined. Samples of composts, nicotine sulphate and sodium arsenate have been submitted for analysis.

5. The writer attended the Second International Congress for Microbiology at London from the 25th July until the 1st August 1936.

Lyamungu
31st March 1937.

H. B. Stent
Chemist

SECTION VII.—Report on Plant Pathology.

Routine.—Diseases of crops other than coffee have been referred to in the annual report of the department for the year ending December 1936.

I have been on duty throughout the period covered by this report and proceed on leave in March 1937. From the 29th April until the 4th December 1936, I was Acting Chief Scientific Officer in charge of the Coffee Research Station; it follows that less time was available for plant pathological work.

Only one unrecorded minor disease of coffee has been observed during the period. Investigations have been continued on several of the known diseases; notes on progress have already appeared in the monthly notes of the station. Six tours of investigation have been undertaken.

Observations on coffee diseases were referred to at a meeting of planters at Arusha in August. A paper was prepared for the Coffee Planters' Days at Nairobi in September 1936, and this was read in my absence through the courtesy of the Senior Plant Pathologist of the Kenya Department of Agriculture. The paper was quoted in the monthly notes of the station.

Publications.—"A Second List of Fungi and Diseases of Economic Plants in Tanganyika Territory" was published in the Kew Bulletin No. 3 of 1936. "A Revised List of Plant Diseases in Tanganyika Territory" was published in the *East African Agricultural Journal*, Vol. 2, No. 4, in January 1937. This latter list combines the two lists previously published in the Kew Bulletin and has a few additional records.

Diseases of Coffee.

Hemileia.—Leaf disease (*Hemileia vastatrix*, B. and Br.) has been recorded during the period in North Mara and in Tukuyu. In February 1936 and in February 1937, spraying experiments were carried out near the Coffee Research Station.

Experiment No. 1 of 1936 consisted of a randomized block of thirteen treatments in quadruplicate, each plot having twelve trees. Control plots were unsprayed. This was on the lines of the Experiment No. 2 of 1935. The object was to compare the efficiency of various fungicides against leaf disease. The treatments consisted of Bordeaux mixture 1·0 per cent plus linseed oil alone, groundnut oil 1·0 per cent plus Agral I 0·25 per cent, groundnut oil alone, four proprietary mixtures, four proprietary mixtures applied dry, and Woburn mixture.

In July and August the plots were examined. As the season advanced it became apparent that the trees were not ideal for the purpose owing to differences resulting from the nature of the soil and the degree of slope of the land. Data for statistical analysis could not be obtained, but naked-eye observations were made on the results of treatments. Of the thirteen treatments, Bordeaux mixture plus linseed oil was the most effective. The effect of linseed oil alone was negligible and the same result was obtained from groundnut oil plus Agral I, and from groundnut oil alone. Very little or no control was obtained as a result of two dustings with each of the four proprietary mixtures applied dry. The four proprietary mixtures which were applied as wet sprays were less effective than Bordeaux mixture: two are more expensive, the third costs the same as 0·5 per cent Bordeaux, and the fourth the same as 0·66 per cent Bordeaux. The third is sold locally and like the others is ready for mixing with water; used at a greater concentration than that recommended it would probably be more effective. In any case its cost compares favourably with that of Bordeaux and it is less troublesome to prepare. The control plots

without treatments were heavily affected, some trees more than others. The rainfall following the treatments in this and the next experiment was unusually heavy, amounting to eighty inches between the dates of spraying and of making observations.

1936 Experiment 2 consisted of a randomized block of ten treatments with controls, each of twelve trees, in quadruplicate. The object here was to compare the efficiency of various stickers and spreaders applied in conjunction with 1·0 per cent Bordeaux mixture. The treatments were Bordeaux alone, Bordeaux plus each of the following: linseed oil, groundnut oil, fish oil soap, a proprietary spreader, sulphite lye, a proprietary wetting compound, alum and resin soda; controls were unsprayed.

The Bordeaux used alone proved to be quite effective, and it was not possible to see any advantage in the addition of stickers or spreaders so far as retention of spray deposit is concerned. This bears out results of experiments elsewhere. The extra cost of the sticker or spreader is not, according to this experiment, found justifiable.

1937 Experiment. On the 15th February an experiment was started on a block of native arabica coffee, in which the crop of each tree had been recorded for the years 1934, 1935 and 1936. The treatments given were 1·0 per cent Bordeaux mixture, 0·5 per cent Bordeaux, and a solution of soluble copper hydroxide; the controls were untreated. Observations will be made in July or August; the experiment will be repeated in 1938. The crop on which the effectiveness of the treatments is to be based (in addition to naked-eye observations) is expected to be small this year.

Disease of Coffee at Mufindi.—This disease was first referred to in Mycological Leaflet No. 16 of 1934. During 1936 the affected areas were visited in March and in June. In March a detailed spraying experiment was started. When examined in June, after an interval of three months, the following information was obtained. The disease throughout the estate and on the experiment area, including controls and guard rows, was very mild. This is explained by the fact that cultural recommendations I made previously had been carried out thoroughly over the whole estate and such treatment had itself resulted in what I later estimated at 95 per cent control of the disease. This result is of sufficient importance to counterbalance the impossibility of obtaining comparative observations on the effects of the individual spray treatments.

Although comparative data between the effects of treatments could not be obtained, it was clear that these were better than the controls and successful so far as even distribution of the spray fluids and their retention on the leaves was concerned. This was in spite of the fact that the rainfall during the three months had been fifty-one inches. Bordeaux mixture, even without any sticker, showed quite good retention, when applied as a fine misty spray.

Comparing the plantation on which the experiment was carried out with a neighbouring coffee plantation abandoned two years ago, the difference in intensity of the disease is very great. In the former about one to five leaves in a hundred had leaf spots caused by this disease, and the number of such spots per affected leaf varied from one to about five. On the other plantation the percentage of affected leaves was in the neighbourhood of eighty and the number of spots per affected leaf varied from one to fifty.

On the first of these two plantations leaf retention was very good, whereas on the second intense leaf-spotting had resulted in heavy leaf-fall. In March this second plantation had a large flush of green cherries, but by June the

majority had become diseased and fallen, and in another month or two a quite negligible quantity would remain. It has to be admitted that even in the first plantation cropping is very limited for other reasons, but what crop exists showed good prospect of reaching maturity in healthy condition. These latter trees have had no shade for the past year, shade trees had been removed entirely instead of being thinned only, with the result that the coffee suffered somewhat from exposure. The latter condition had been lessened considerably by the bracken covering on the sides of the trees exposed to the cold winds.

The cultural practices which prevented this disease reaching significant proportions had as their object the encouraging of free circulation of air and reduction of humidity in and around the coffee trees, for it is humidity combined with cold upon which the growth of the fungus chiefly depends.

Tea, which is more adapted to the conditions of the area, is growing without shade, and where shelter is moderate the disease is slight or even negligible.

As regards laboratory study of the fungus, many cultures on artificial media, and inoculations of coffee growing on the site, have been made. In no case have sclerotia or fruiting bodies been observed. The *gemmae* which are so characteristic of the fungus growing on the plants have not developed in culture. There is no stage of the fungus by which to discover its systematic position, and likewise no possibility at present of providing a name by which to refer to it.

The general problem of coffee culture at Mufindi and the significance of the disease were described in a paper read at Nairobi in September.

Collar Dry Rot of Coffee.—An account of this disease was given in the annual report of the department 1935, pages 108-9.

The site of the disease was visited again in June. Thanks to the Acting Director of the East African Agricultural Research Station, a glasshouse was placed at my disposal for experiments. Seedling arabica with disease and with mealy-bugs (*Pseudococcus brevipes*), were grown in large pots. When examined in November it was observed that the mealy-bugs had disappeared with the absence of ants, as was anticipated. On the other hand the disease had progressed without, however, any symptoms in the foliage. Some plants were taken up for laboratory study; others were left for further observations on the progress of the disease, as it is desirable to compare the ultimate stages of the disease as it starts in the seedlings with that observed in plants several years old in the field and to come to some conclusion regarding their relationship.

The seedling disease takes the form of callused canker-like swellings at the collar, in a few cases with considerable constriction below. On the swellings the epidermis is loose and flakey. Attempts to infect healthy seedlings with the mealy-bugs in the glasshouse were unsuccessful; these insects had died out, again no doubt on account of the absence of ants. Seedling coffee at the Coffee Station is being grown alongside pineapples infected with what will probably be confirmed as the same mealy-bug as occurs on the affected coffee in the Usambaras. It will be observed if the bugs are transferred and whether disease develops.

The external and the internal symptoms of the disease in seedlings and older plants are very similar, and it is expected that a more critical examination of the material will support the view that both diseases have the same origin.

Robusta coffee remains free from both the particular mealy-bug and the disease; it is unfortunate that grafting of arabica on to robusta stock had not yielded satisfactory plants.

A Cankering of Coffee Stems.—An unusual disease of coffee was first noticed in July 1936 by Mr L. F. Higgens, Agricultural Assistant. It is restricted to a few native plantations in the Moshi district at an elevation of 4,400 feet. One plot of eight to thirteen years old Bourbon coffee was the most affected; two-year old trees in that plot appeared to be clean.

The shade in these plantations is afforded by scattered bananas. The soil is red and deep, deficient in humus, and cracks readily in dry periods. In 1931 the trees had die-back but recovered. The only spray treatment the trees had received previous to July when the disease was noticed had been an arsenic bait spray for Antestia. In July the leaves were healthy and green and the trees were bearing a small crop.

The disease occurs above ground. The main stem at the base of each of the branches has a cankered appearance, with the bark loose and peeling off, and that part is sometimes flat or slightly sunken. Sections through cankered stems and branches show discolorations at depths which would indicate that the disease first started about two years ago. The lower rings of dark diseased wood have in most cases become callused over, and the outermost is in process of becoming grown over by callus from the healthy wood at the sides. Examination has revealed no fungus, and at the time of writing it is thought that puncturing by insects is a possible cause worth investigating, for the symptoms are not very unlike those found in the gnarled stem canker of tea.

Yellowing of Coffee.—Coffee and Canadian Wonder beans on one plantation were reported early in 1936 to be suffering from an unusual severe yellowing and leaf-fall. It was soon afterwards concluded that this was a soil problem; as it appeared to have a regional rather than a purely local interest, the Soil Chemist, Amani, agreed to examine the soil, in the absence of the Chemist of this station on leave. A preliminary examination indicated that the soil has poor drainage and aeration characters and that it is low in nitrates. On the evidence so far obtained, it is probable that gypsum would remedy the condition, and a trial is being made. While the cost renders gypsum impractical, the trial may yield some useful information, and further investigation may indicate practicable remedial measures.

Damping-off Disease of Coffee.—An excessive number of deaths of coffee cuttings in frames was brought to my attention in February 1937. Some of the deaths were due to failure of the cuttings to become established and to later invasion by soil bacteria causing a black wet rot to spread up the shoot. But there was present in many of the cuttings a species of *Rhizoctonia*, which is one of the fungi capable of causing damping-off disease under conditions which are more or less essential to the successful propagation of coffee cuttings. Seedlings in boxes were likewise affected.

Control measures were at once started, but it is too early to say with what success: it was essential to retain the susceptible but apparently healthy cuttings if at all possible, as they could not be readily replaced. Diseased cuttings were removed and burned, and the remainder were sprayed with Cheshunt compound. General sanitation measures are being enforced. The information which has come to light is of general interest, and will be incorporated in a revised edition of the Leaflet No. 4, which deals with damping-off.

GEO. B. WALLACE
Plant Pathologist

STATEMENT OF EXPENDITURE FOR THE PERIOD OF THE 1st JANUARY TO THE 31st DECEMBER 1936.

Colonial Development Fund—4, Coffee Research Station.

I.—Personal Emoluments.

	Provision Shs		Expenditure Shs cts
1. Chief Scientific Officer			21,814 52
2. Chemist			14,250 00
3. Agricultural Assistant			6,362 90
4. European Clerk			6,990 00
5. Asiatic Clerk			2,728 67
6. (a) Laboratory Assistant	60,080	...	—
(b) African Assistants			719 69
7. (a) Mechanic			2,400 00
(b) African Assistants			810 00
8. African Overseer			100 00
9. Messengers			362 68
	60,080	...	56,538 46
Transferred to Items 10 and 11	3,396		
	56,684		

II.—Other Charges.

10. Incidental Expenses:			
(a) Stationery	840	...	535 10
(b) Contingencies		...	402 22
	840	...	937 32
Transferred from Personal Emoluments	205		
	1,045		
11. Farm Operations and Experimental Work:			
(a) Labour			6,859 94
(b) Recorders			6,491 60
(c) Field Experiments off Station ...			1,259 50
(d) Upkeep and Maintenance of Motor Vehicles	19,080	...	2,102 08
(e) Maintenance of Power, Gas and Water Plant			1,493 96
(f) Books and Periodicals			1,157 82
(g) Laboratory Equipment and Materials			2,794 48
	19,080	...	22,159 38
Transferred from Personal Emoluments	3,191		
	22,271		

Appendix A—Loan Expenditure—14, Coffee Research Station, Capital Expenditure (Development).

(a) Labour	20,000	...	4,085 59
(b) Materials		...	16,187 09
	20,000	...	20,272 68

LIST OF COFFEA SPP. AT PRESENT ON THE STATION.

Coffea arabica.
- ,, Variety Kent's local.
- ,, ,, ,, imported.
- ,, ,, Blue Mountain.
- ,, ,, Rasha Rasha Blue Mountain.
- ,, ,, ,, Hybrid.
- ,, ,, ,, 1.
- ,, ,, ,, 2.
- ,, ,, Maragogipe.
- ,, ,, erecta.
- ,, ,, columnaris.
- ,, ,, Padang.
- ,, ,, San Ramon.
- ,, ,, Bourbon.
- ,, ,, Series A
- ,, ,, ,, E } Kenya selections.
- ,, ,, ,, L
- ,, ,, Amphillo.
- ,, ,, Harrar.
- ,, ,, ,, Series M.
- ,, ,, Uganda 27/35.
- ,, ,, Bronze tip Mufindi.
- ,, ,, Pasam.
- ,, ,, La Palma.
- ,, ,, Barbarina.
- ,, ,, Puerto Rico.
- ,, ,, Tumbadir.
- ,, ,, D'Antigue.
- ,, ,, Barbarina (yellow cherry).
- ,, ,, Santiago.
- ,, ,, Mibirizi.
- ,, ,, Maragogipe hybrid.
- ,, ,, Amani selections.
- ,, ,, ,, hybrids.
- ,, ,, Haiti.
- ,, ,, Bronze leaved (Sinclair).
- ,, ,, Upright type.
- ,, ,, Dark leaved.

Coffea robusta.
- ,, Variety Bukobense.
- ,, ,, Quillou.
- ,, ,, 124/01 Java.
- ,, ,, Uganda (wild) (two types).
- ,, ,, Amani (four types).
- ,, ,, (Sudan).
- ,, ,, (Arusha).

Coffea congensis hybrid.
- ,, stenophylla.
- ,, excelsa.

Coffea liberica.
,, travancorensis.
,, canephora.
,, eugenoides.
,, mufindensis.
,, khasiana.
,, sp. Madagascar.
,, sp. Mocambique (? stenophylla).
,, sp. Kiboriani mountains.
,, Dybowski.
,, micrantha ?

Appendix III.

LIST OF COVER CROPS AND GREEN MANURES ON THE STATION.

Small amounts of seed of certain of the following are available for distribution in small quantities:—

Alysocarpus Violaceous
Amphicarpa africana
Argryrolobium Fischeri
Cajanus indicus
Calapogonium mucinoides
Canvallia ensiformis
Cassia australis
,, Kirkii
,, mimosiodes
,, sophora
,, sp.
Centrosema pubescens
,, Plumieri
Cornilla varians
Crotalaria alata
,, anagroides
,, cleanifolia
,, Dilloniana
,, Grantiana
,, Juncea
,, Kirkii
,, laburnifolia
,, lachnocarpodes
,, nataliensis
,, polysperma
,, retusa
,, spectabilis
,, striata
,, tephogesa
,, trifoliata
,, usamariensis
,, ugandense
,, zanzibarica
,, senegalensis
Dolichos lablab
Fagopyrun esculentum
Glycine javanica (two types)
Indigofera endacophylla
,, erecta
,, tinctora
,, tettensis
,, hirsuta
,, spp.
Mimosa invisa
Mucuna spp.
Phaseolus calcartus
,, lunatus
,, vulgaris
Pisum sativum
Pueraria Thunbergiana
Smithia ruenzoriensis
Tephrosia candida
,, densiflora
,, noctiflora
,, toxicaria
,, congestiflora
,, uniflora
,, Volgellii
,, nyikensis
,, rigida
,, spp.
Teramnus labialis
Vicia faba
Vigna gracilis
,, Hosei (Dolichos)
,, triloba
,, unguiculata
Pseudarthria Hookeri
Lupinus sp.
,, sp. (Sweet German)
Desmodium salicifolium

LIST OF SHADE TREES ON THE STATION.

Milletia oblata
Albizzia lebbek
„ stipulata
„ molucanna
„ maranguensis (fastigiata)
„ lopantha
Spathodia nilotica
Acrocarpus fraxinifolius
Brachyton populneus
Calpurnea aurea
Entrolobium timbouava
Phytolacca dioica
Samanea saman (Pithecolobium)
Erythrina velutina
Croton melagocarpus
Maesopsis Emenii (birchmoides)
Erythrina tomentosa
„ kaffra
Ficus sycomorus
„ malatocarpus
„ Thonningii
Cytisus alba
Entada abbysinica
Adenanthera pavonia
Jacaranda mimosaefolia
Schinus molle
Glyricidia maculata
Cassia didymobotria
Grevillea robusta
Raowaolfia inebriens
Treema guineenensis
Cedrella toona
„ odorata
Inga edulis ?
Machaerium tipu
Ricinus sp. (Giant Castor)
Sesbania aegyptiaca
„ grandiflora
„ punctata
„ sp.
Tecoma serratifolia
Tetrapleur tetrapleur
Terminalia catappa
Solanum robustum
Schizolobium excelsum
Vitex keniensis
Leucaena glauca

SAMPLE OF FULL BEANS DATA

Tree No.	ESTATE F.							PERCENTAGES												
													BARS				SIEVES			
	Picking	No. of sample	Weight ozs.	Parchment ozs.	Clean ozs.	100 beans in gr.	Average length in mm.	Vol. in c.cm.	Parchment to Cherry	Clean to Parchment	Clean to Cherry	Pea Berry	L. 9	Large	Medium	Small	Remainder	8	6A	4	Remainder
Random	1	29	56	11*	8*	14·5	9·4	0·11	19·6	69·7	13·7	11·6	2·7	13·3	2·5	3·4	80·9	47·8	12·8	8·1	31·2
Random	2	66	64	16	11	17·7	9·7	0·14	24·2	73·7	17·9	14·4	3·2	19·9	7·4	15·6	57·1	78·2	6·0	6·0	9·9
Random	3	127	64	14	11	16·0	9·5	0·12	21·1	80·4	17·0	14·8	1·5	17·5	4·3	6·5	71·8	53·2	15·8	11·5	19·4
Random	4	189	64	13	11	16·3	9·0	0·13	21·1	81·5	17·2	14·4	2·4	15·9	4·3	9·8	70·0	60·7	13·0	9·1	17·1
Random	5	338	64	15	12	17·5	9·2	0·12	24·9	82·8	19·1	11·4	7·7	22·8	9·3	17·9	50·0	66·2	15·1	7·8	11·0
212	2	68	27	4	3	12·5	8·7	0·11	14·3	77·8	11·1	21·6	–	19·7	8·0	8·0	64·3	29·2	14·8	14·0	41·9
212	3	129	38	7	5	14·5	8·7	0·12	18·4	72·4	13·3	24·1	4·4	25·9	5·4	5·8	62·9	37·0	16·3	12·0	34·8
212	4	195	41	8	6	13·9	9·0	0·11	19·5	79·2	15·4	17·9	2·0	17·8	3·2	6·6	72·4	50·7	13·8	10·7	24·8
212	5	343	17	3	2	13·0	9·0	0·12	18·5	81·8	15·1	21·1	3·2	18·1	–	11·6	70·2	35·3	17·6	12·9	34·2
267	1	33	18	3	2	15·0	9·4	0·12	17·6	78·9	13·9	11·5	–	10·7	4·6	7·9	76·8	53·0	16·0	11·0	20·0
267	2	69	33	6	5	16·4	9·3	0·14	19·7	80·2	15·8	21·5	–	24·7	5·6	6·4	63·3	46·0	13·4	13·4	27·2
267	3	130	40	7	6	15·1	8·8	0·12	19·2	80·4	15·4	19·1	4·6	22·8	5·5	8·6	63·1	47·9	15·3	11·4	25·4
267	4	196	42	9	7	13·4	9·1	0·12	18·6	81·5	15·1	16·7	2·0	16·4	4·3	7·0	72·3	58·6	11·0	11·1	19·3
267	5	344	40	8	6	14·4	8·9	0·12	21·0	77·2	15·7	16·2	3·6	18·0	2·8	6·0	73·2	51·6	16·0	10·2	22·3
269	2	70	28	5	4	15.8	9·5	0·12	19·6	77·9	15·3	23·1	4·8	25·7	15·7	1·7	57·0	50·9	15·7	9·3	24·1
269	3	131	40	8	6	14·9	8·8	0.12	20·4	79·6	16·3	24·4	3·9	26·6	6·2	9·9	57·3	52·9	12·9	9·8	24·4
269	4	197	48½	10	8	16·1	9·2	0·13	20·6	80·0	16·5	15·5	2·9	20·4	4·1	12·0	63·5	69·2	9·5	6·0	15·3
269	5	345	22	5	4	15·2	8·7	0·11	23·1	82·1	18·9	20·0	7·0	29·5	8·8	14·0	47·7	68·4	11·4	6·9	13·4
502	1	30	5½	1	·75	13.2	8.9	0·11	19·4	76·8	14·9	12·1	6·0	16·4	6·0	7·8	69·8	49·1	13·8	10·8	26·3
502	2	71	37	7	6	13.5	8·7	0·11	19·4	78·7	15·3	26·1	5·3	26·9	5·6	7·4	60·1	33·0	17·4	12·7	36·8
502	3	132	39	8	6	15·1	9·2	0·12	20·5	81·2	16·7	28·8	4·6	26·2	3·5	7·8	62·5	22·8	6·6	9·3	61·3
502	4	198	48½	10	8	14·4	9·2	0·12	20·5	82·2	16·8	15·6	1·6	17·0	4·2	6·8	72·0	44·2	19·1	11·5	25·2
502	5	346	22½	5	4	15·5	9·0	0·13	20·0	83·3	16·7	13·0	10·4	30·5	8·4	12·3	48·7	58·3	11·8	10·7	19·2
611	2	72	45	10	8	14·6	9·3	0·12	21·7	79·2	17·2	19·2	4·0	22·9	5·6	9·8	61·7	61·1	13·1	7·9	18·0
611	3	133	40	8	7	16·0	8·7	0·13	21·2	79·8	17·0	24·9	2·4	51·0	13·4	9·7	25·9	48·8	13·3	11·1	26·9
611	4	199	48½	11	9	15·3	9·2	0·13	22·2	82·0	17·9	15·4	2·1	16·4	3·6	4·2	75·8	59·3	13·8	6·1	20·8
611	5	347	28	6	5	15·0	9·0	0·12	21·6	82·3	17·9	13·8	0·9	14·4	4·4	8·7	72·5	58·9	13·6	10·5	17·0

*These figures are to the nearest ounce for the purpose of reproduction.